This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

THE

PNEUMATIC DISPATCH,

WITH ILLUSTRATIONS:

A Compilation of Notices and Information concerning the Pneumatic
System of Transportation as now Building and Operating in
England; together with Accounts of its first Trial in
the United States, and of Proposed Applications
of the System to Passenger and Postal
Service:

INCLUDING

Descriptions of Sub-Aqueous and other Tunnels

BY ALFRED E. BEACH.

New-York:
THE AMERICAN NEWS COMPANY, NASSAU STREET.
1868.

Entered, according to Act of Congress, in the year 1868, by

ALFRED E. BEACH,

in the Clerk's Office of the District Court of the United States for the Southern District of New-York.

INTRODUCTION.

THE information here presented consists mostly of compilations from reliable sources, which will, it is believed, be of interest to those who are desirous of forming a just estimate of the value of the Pneumatic system as a commercial enterprise.

The accounts given exhibit the practical progress of the system from the first public experiment at Battersea Fields, in 1861, down to January, 1868. During this period of seven years the Pneumatic system has been introduced in London with entire success, where it is now in regular operation in connection with the postal service.

Thorough practical trials with reference to passenger transportation have also been had in London, which have so completely demonstrated the success and importance of the system as to warrant the construction of a Pneumatic Passenger Railway from Charing Cross, under the Thames River, to the Waterloo station of the Southwestern Railway. This road is not yet wholly completed.

In this country the first public trial of the Pneumatic Railway took place at the American Institute in the fall of 1867, when many thousands of passengers enjoyed the atmospheric ride. Charters for Pneumatic Railways have been granted in the States of Pennsylvania, New-Jersey, Connecticut, and Massachusetts. Applications for charters are pending before the Legislatures of New-York and other States.

The engravings of the London Pneumatic Railways are from drawings taken from the works.

ALFRED E. BEACH.

NEW-YORK, January, 1868.

THE PNEUMATIC DISPATCH.

BY ALFRED E. BEACH.

CHAPTER I.

THE PNEUMATIC DISPATCH — ITS GENERAL PRINCIPLES, CHARACTERISTICS, CAPABILITIES, AND ADVANTAGES — FIRST PUBLIC TRIAL AT BATTERSEA FIELDS, NEAR LONDON, IN 1861 — PARTICULARS CONCERNING ITS CONSTRUCTION AND MODE OF OPERATION — ENTIRE SUCCESS OF THE EXPERIMENT.

THE method of communication known as the Pneumatic Dispatch consists of a railroad track inclosed in a tube, the cars being driven by atmospheric pressure. The car, in effect, is a piston, moving within the tube.

The velocity of the car is in proportion to the degree of atmospheric pressure, which is produced by means of a fan or blower, operated by a stationary steam-engine.

The mechanism for operating the Pneumatic Dispatch is of the simplest description. A tube, a car, a revolving fan! Little more is required. The ponderous locomotive, with its various appurtenances, is dispensed with, and the light aerial fluid that we breathe is the substituted motor.

The Pneumatic Dispatch is not a chimera, nor merely an untried, undeveloped novelty. It has been in practical operation in London for the last seven years, where its capabilities for useful service have been tested in the most careful and thorough manner. The results of these years of actual employment conclusively show that it has economical advantages over the present railway system, and there seems little reason to doubt that its introduction will become extensive.

The Pneumatic Dispatch presents theoretical facilities for obtaining high velocities. Air rushes into a vacuum at the rate of 700 miles an hour. If the proper mountings for a light piston and finish for the tube could be realized, it is supposed that a velocity of piston approaching this might be obtained. The experimental pneumatic passenger cars at Sydenham ran through the tube at the rate of twenty miles an hour, with an atmospheric pressure of only two and a half ounces to the square inch. On the old Croydon Atmospheric Railroad, where the small slotted air-tube was used and the leakage was very great, the cars could be driven at a velocity of a mile a minute, or sixty miles an hour.

It is believed that, under the improved system of sending the car through the tube, a speed of 100 miles an hour may be safely realized, or four times the average speed of many of our best railroads.

The great destroying agent upon all roads is the locomotive, which, with its tender, often weighs thirty tons. To support this immense mov-

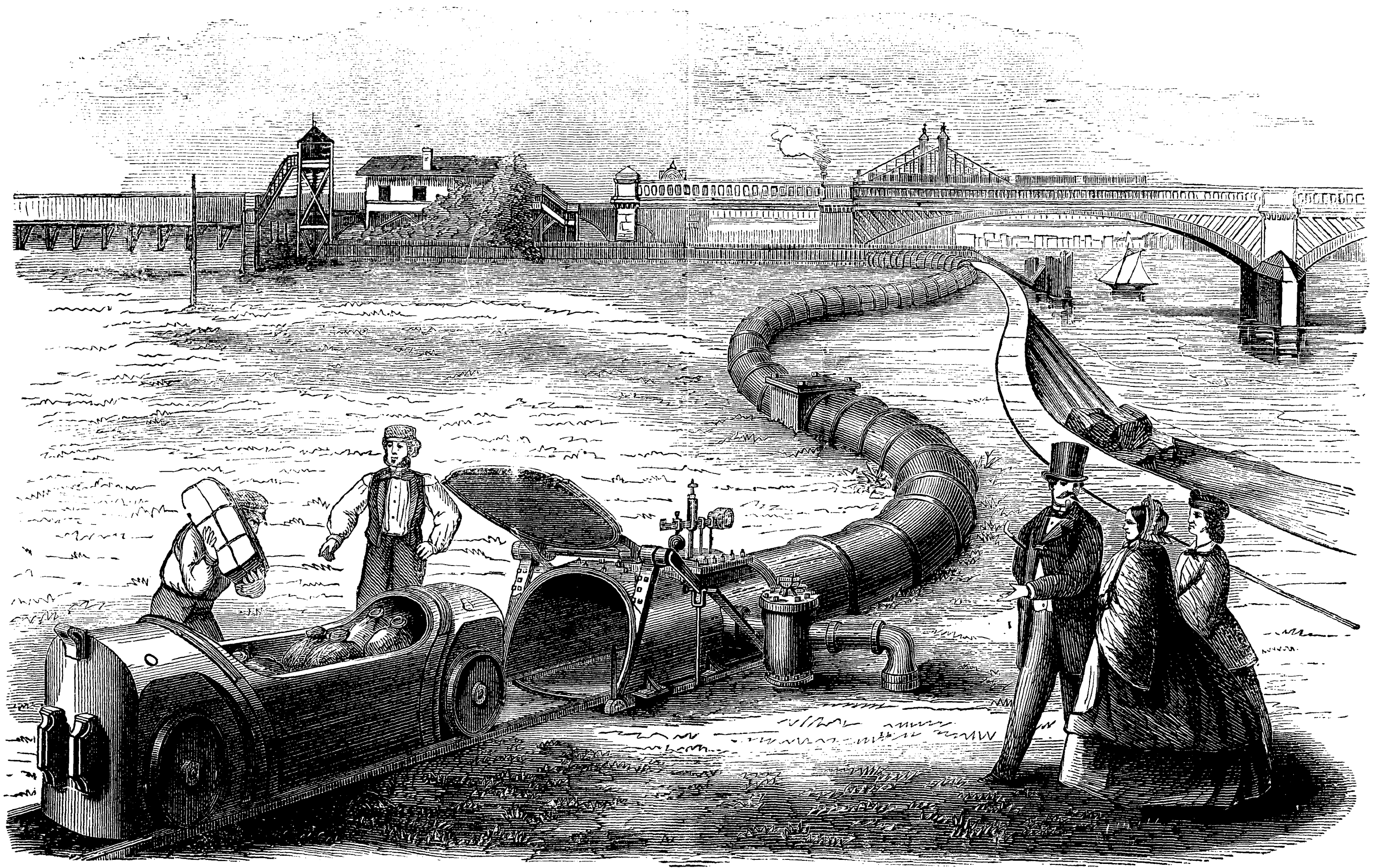


Fig. 1.—The Pneumatic Dispatch—as first operated at Battersea Fields, London, in 1861.

ing burden, the bridges, rails, and superstructure must have corresponding strength, and even then they are rapidly battered to pieces and rendered unsafe.

To resist the wrenchings of the locomotive and the rough usages of the track, the cars must be much more heavily timbered and framed than is needful to support the loads they carry.

In the pneumatic system no locomotives are employed. Hence, the roadway and cars may be very light. The whole pneumatic way being under cover, the road-bed is preserved from damage by the elements, and the transit of the cars is not impeded by snow, ice, floods, or falling rocks. For freight purposes, simple platform trucks, strong enough to support the load, are sufficient. Thus the enormous dead weight of the sides, frames, ends, and roofs of the ordinary box cars is avoided.

Laid through the country, the tube will be wholly or partly buried in the earth, its whole business being performed with the celerity of Æolus, with the silence of Somnus.

The expensive bridges, culverts, trestle-works, cuts, and embankments, required upon common railroads, are not wanted in the pneumatic system. The tube forms the bridge over small streams, dives under broad waters, and rests securely upon marshes. No screeching whistles or jangling bells disturb the community, no turnpikes require to be guarded; there is no running down of the helpless, no mangling of passengers, no burnings from sparks; no fearful dangers of any kind attend the use of the Pneumatic Dispatch.

It is impossible to say what casualties are likely to attend its working; but, from the elastic nature of the motor, we conclude that they will be rare in number, and less violent in their nature than those that are experienced upon common railroads. During the whole seven years' use of the pneumatic system in London, we believe that not a single accident to person has ever been recorded; nor do we know that there has even been so much as a break-down of any pneumatic car.

◆

First Public Trial of the Pneumatic Dispatch at Battersea Fields, near London, in 1861.

[From the London Mechanics' Magazine, July 19, 1861.]

THE PNEUMATIC DISPATCH COMPANY.

On Wednesday last some experiments, on a rather large scale, were made on the right bank of the river, and immediately below the railway bridge, Battersea, with a view to testing the efficiency of the novel mode of transmitting goods and parcels proposed by the above-named company. The mechanical arrangements in connection with the experimental line of cast iron tubing—which, like a huge black snake, stretches for more than a quarter of a mile along the river side—are few and simple.

Under a temporary shed a high-pressure steam-engine, of thirty horse-power, made by Watt & Co., and having its cylinder placed at an angle of forty-five degrees, is erected, and it gives direct motion, through the medium of a crank, to a large disk of sheet-iron. The disk runs on tubular bearings, and narrows from about two feet six inches in breadth at its centre to three inches at its circumference, its diameter being eighteen feet. Its interior contains simply four arms to which the sheets of iron are fastened, and which serve as fans or exhausters. Through the hollow bearings, upon which the disk is made to rotate at a speed of from one hundred and fifty to two hundred revolutions per minute, a communication exists with a vacuum-chamber below, and, by the laws of centrifugal action, the latter is speedily exhausted, to a certain extent, of air. The speed of the disk, in fact, determines that extent, and a water-barometer registers it. The air rushes out with considerable force from the periphery of the disk.

Between the vacuum-chamber and the pneumatic tube, which is two feet nine inches high by two feet six inches in breadth, and a transverse section of which resembles that of the Thames tunnel, there are fitted valves with hand-levers for opening and shutting them. These may be said to comprise the whole of the motive and propelling agencies of the pneumatic system; and it must be allowed that they are not complicated, or likely to get out of order.

The tube has been laid down in Battersea Fields in such a manner as to test severely the practicability of the scheme. It has several very sharp curves and steep gradients throughout its length, and is socket-jointed, so as to leave its interior, which is just as it came from the sand, free from obstruction. The carriages are five feet in length, of sheet-iron, and each runs upon four cast iron wheels of eighteen inches in diameter. The rails, so to speak, are *cast* in the bottoms of the tubes, and require, therefore, no "laying" but that which the setting of the tubes themselves gives them. A few strips of vulcanized india-rubber screwed round the circumference of the fore end of the carriage constitute the piston. This, however, by no means closely fills the tube. In fact, there is fully three eighths of an inch clear between the exterior of the piston and the interior of the tube. There is no friction, therefore, and, singular to say, the leakage of air does not interfere with the speed of transit. This can only be accounted for by the large end area which the carriages have, in comparison with the small area of leakage space, and the comparatively low vacuum required.

On Wednesday last the first experiment made was by loading a carriage with one ton of cement, in bags, and entering it into the open end of the tube. Upon a given signal Mr. Rammel, the engineer to the company, caused the starting-valve to be opened, the water-barometer showing a column seven inches in height, and the disk running at a rate of one hundred and fifty revolutions per minute. In fifty seconds after, the carriage, with its contents, found its way into the engine-house, through a door at the end of the tube, which it forced open, and then ran forward on rails to a butt placed to stop its progress. Next, two tons weight were placed in one of the carriages, and its transit occupied eighty seconds, under similar circumstances. The vacuum was now lowered until the barometer-gauge showed two inches of water only, and a living passenger, in the shape of a not very handsome dog, was placed, with one ton weight of dead stock, in a carriage. The signal was made by the workmen at the open end of the tube, the communicating valve was opened, and in one minute and a half the carriage and its four-legged guard were in the engine-house, the latter apparently not at all the worse for the exhausting process to which he had been subjected. Other experiments of an equally satisfactory nature followed, and, on the whole, we augur well of the entire scheme. Sir Joseph Paxton, H. W. Blake, Esq., and other gentlemen of scientific eminence were present on the occasion, and expressed their pleasure in witnessing the experiments.

[From the London Engineer, July 26, 1861.]

PNEUMATIC DISPATCH.

THE atmospheric post has been at work for a few days, and experimentally, in Battersea Fields. An iron tube, upward of a quarter of a mile long, has been laid along the river's bank, and mail-bags, parcels, and even adventurous navvies have been whisked through at the rate of twenty-five miles an hour. Those who, some twenty years ago, witnessed the working of the atmospheric railway, may discover nothing new in the principle. But the application is altogether different. There is still the tube and the exhausting apparatus, but the load, instead of being drawn over rails laid alongside of the tube, goes through it. No self-sealing valves, therefore, are necessary. As, also, the load is comparatively light, a very low degree of exhaustion suffices for every purpose of propulsion. Air flows into a vacuum with a velocity of about one thousand feet per second, or nearly seven hundred miles an hour, and it would be possible to send a light object at something approaching this rate through a smooth tube, from which all the air had been first exhausted. Even with such a vacuum as could be maintained in the Croydon Railway tubes, and with all the load attached, the trains sometimes attained a speed of nearly a mile a minute.

The tube, in its course, is sharply curved, and presents also steep gradients, in one case a slope of one in twenty, equal to the average rise of Holborn Hill. The minimum curve is of forty feet radius. The air is exhausted, from near one end of the tube, by means of an exhausting apparatus, from which the air is discharged by centrifugal force.

The invention of the arrangements above described is due to T. W. Rammell, Esq., C. E., the Secretary of the Pneumatic Dispatch Company. This company has been organized under the chairmanship of the Marquis of Chandos, the vice-chairman being Captain Huish. It is the intention of the company, now that they have obtained parliamentary powers for opening the streets to lay down their tubes, to establish a line between St. Martin's-le-Grand and one of the district post-offices, and ultimately to extend their system throughout the metropolis, so as to connect the railway stations, public offices, etc. Both these services could be profitably performed, it is urged, by the Pneumatic Dispatch, at a speed of thirty miles an hour, without obstructing the thoroughfares, and with other advantages which sufficiently suggest themselves upon reflection.

[From the Scientific American of October 5, 1861.]

PNEUMATIC DISPATCH.

A COMPANY has been formed in London, under the title of the Pneumatic Dispatch Company, for establishing lines of pneumatic tube for the speedy conveyance of letters and parcels. The chief feature of the invention consists in propelling a train of carriages through a tube by the creation of a vacuum before them; the tube being, in fact, the cylinder, and the carriages the piston. A piece of ground adjoining the Victorian Railway bridge at Battersea, and belonging to the Vauxhall Water-works Company, and London and Brighton Company, has been selected for testing the project. Here upward of a quarter of a mile of the tubing has been laid down, various irregular curves and gradients being introduced to show that hills and valleys would not prevent the effective working of the system. The apparatus certainly works well.

Some successful experiments were lately made. One trip was made in sixty seconds, and a second in fifty-five seconds, the distance being a quarter of a mile. Two gentlemen occupied the carriages during the first trip. They lay on their backs on mattresses, with horse-cloths for coverings, and appeared to be perfectly satisfied with their journey. It is calculated that the carriages will eventually move through the tubes at the rate of from thirty to forty miles an hour.

CHAPTER II.

LAYING DOWN OF THE FIRST PNEUMATIC TUBES UNDER THE STREETS OF LONDON—SUCCESSFUL INAUGURATION OF THE ENTERPRISE—CONNECTION OF RAILWAY STATIONS AND THE GENERAL POST-OFFICE BY MEANS OF THE PNEUMATIC TUBES—DESCRIPTION OF THE MANNER OF SENDING THE MAILS THROUGH THE TUBES—REPORT OF THE DIRECTORS—INSPECTION BY THE POSTMASTER-GENERAL—EXPENSES OF WORKING—DESCRIPTION OF THE MACHINERY—EXTENSION OF THE WORKS—INAUGURATION OF THE HOLBORN STREET STATION.

[From the London Mechanics' Magazine, February, 1863.]

INSPECTION OF THE PNEUMATIC DISPATCH BY THE POSTMASTER-GENERAL AND SIR ROWLAND HILL.

On Monday last, Lord Stanley, of Alderley, the Postmaster-General, and Sir Rowland Hill, the Secretary of the Post-Office, officially inspected the working arrangements of the branch tube of the Pneumatic Dispatch, (which has been laid from the Euston station to the north-western Post-Office, in Eversholt street,) previous to the transmission of the mails between the two places above-mentioned; the Post-Office authorities having conceded this privilege to the Pneumatic Dispatch Company. The time appointed for the inspection was half past twelve P.M., and on the arrival of the Postmaster-General and Sir Rowland Hill at the station, within the boundary of the Euston terminus, they were received by Sir Charles Rich, one of the directors, Mr. Margery, and Rammell, the secretary and engineer of the Pneumatic Dispatch; Messrs. Blake and Stewart, of the London and North-Western Railway, being among those present. The working arrangements were thoroughly explained by Mr. Rammell, the engineer, and trains of cars were rapidly propelled backward and forward through the tubes. The cars contained heavy weights, being principally loaded with stout planks, and, on the signal being given by Wheatstone's admirable telegraph, they were dispatched to the other end of the tube, with a pressure of about four ounces, in a few seconds over a minute, the average up the incline being about one minute twelve seconds, returning by vacuum in one minute five seconds. The mail-bags, upward of 120 per day, will be blown through the tube in fifty-five seconds to the Post-Office, Eversholt street, the usual time occupied by the mail-carts being at present about ten minutes. Two persons were conveyed, in the presence of the Post-Office authorities, through the tube, and returned by vacuum without having experienced the slightest discomfort. Having fully examined the operation of blowing the cars from Euston, the visitors proceeded to the station at the other end of the tube. This is situated underground, beneath the roadway of a small turning leading from Eversholt street, and is close by the side of the North-western District Post-Office. Here the very interesting operation of sending the cars back to Euston was explained by Mr. Rammell; and two cars having been placed within about a foot of the open tube, a vacuum was created, and they were drawn with a rush into the tube, the small station reverberating with the sound of the receding train. This concluded the experiments of the day, and, on leaving, both Lord Stanley and Sir Rowland Hill appeared favorably impressed with the entire working of the system, the Postmaster-General observing that it appeared, from the experiments, to be very satisfactory and very efficient. Previous to leaving the station at Euston, Lord Stanley descended with Mr. Rammell into the air-chamber of the revolving disk, the motive-power of which consists of a fifteen horse-power engine. The next step of the company will be to lay tubes connecting the markets of London with Camden goods-station, with a tube to the General Post-Office, and Pickford's depot, in Gresham street, and these operations will eventually tend to revolutionize the carrying system of the metropolis, and relieve the crowded state of our principal thoroughfares.

[From the London Mechanics' Magazine, July 31, 1863.]

REPORT OF THE DIRECTORS OF THE PNEUMATIC DISPATCH COMPANY.

THE Directors of the Pneumatic Dispatch Company state in their report that the experimental tube and machinery have been removed from Battersea, and laid underground from the Euston Station of the London and North-Western Company, to the District Post-Office, in Eversholt street. The length of the tube is 600 yards. On the 20th of February last, the Post-Office authorities intrusted the company with the transmission of the mails. From that date the service of the district has been entirely performed by the company. Thirty trains per diem (Sundays excepted) have been dispatched with perfect regularity, and upward of 4000 trains have run without impediment or delay. The time occupied in the transmission has not exceeded seventy seconds. The daily cost of working has averaged £1 4s. 5d., and five times the number of trains could have been conveyed without any appreciable increase of expense. Confirmed in their views by this result, the directors proceeded to carry out the decision of the last general meeting, by the issue of a capital sufficient to enable the company to lay a main line of tube fifty-four inches in diameter, with the necessary stations, appliances, and machinery, from the Euston station to the General Post-Office, in St. Martin's-le-Grand, and forward to Gresham street. This capital having been subscribed, the directors entered into contracts with Mr. Barrow, of Stavely, Messrs. James Watt & Co., and Messrs John Airel & Son, for its completion. The length of this tube will be nearly two and one half miles, and the entire cost, so far as can be foreseen, including the laying, station-accommodation, and the necessary apparatus and pumping engines, will be about £65,000. The whole route has been carefully examined and definitely determined. From the active measures taken by the contractors in the preparation of the tube and engines, the directors hope to commence laying the line at an early date, and will press forward its completion with all practicable expedition. A considerable portion of the further issue of shares has been taken up by the original proprietors and the contractors, and the remainder has been allotted among seventy-six new shareholders.

[From the London Practical Mechanics' Journal, June 1, 1863.]

THE PNEUMATIC DISPATCH.

The Pneumatic Dispatch, as its name imports, was originally conceived as a method of carrying letters or dispatches only, and proposed its arrangements to be on a very small scale. Though bearing the same name, it has become, in the hands of Mr. Rammell, C. E., who may be viewed as the creator of the pneumatic arrangements now in use at the Euston terminus of the London and North-Western Railway, a method of transport applicable upon almost any scale, and to materials of whatever sort, or even to passengers. The apparatus actually in use is applied to the transport of the mail-bags, as they arrive by the line of railway, from the terminus to the District Post-Office in Eversholt street—distant about 1800 feet.

Almost close to the arrival platform at the Euston terminus is seen a small, newly finished, one-story building with a slender chimney-stalk at one side. This is, as the board above the doorway tells, the present terminus here of the Pneumatic Dispatch. Descending two or three steps, we are in the interior, and find a small cast iron tunnel, with arched top and nearly flat bottom, carrying a pair of rails, one at either lower angle, and about two feet nine inches high, by nearly the same greatest width, passing out through the wall at one side. The rails, which are on the floor level, cross it, and at the opposite wall appear to run into a corresponding tunnel; this is, however, only a *cul de sac* of a few feet in length, and its use is merely to afford an *air buffer* to the mail-bag carriages when arriving back here from Eversholt street office, should their velocity be such as to require it, which is seldom the case.

In the middle of the floor, upon the rails between these two tunnel-mouths, we observe two or three iron four-wheeled wagons, formed in the shape of hollow, cradle-like boxes of considerable capacity, which conform externally to the general form of the tunnel-tubes they are to pass through, but have an absolute clearance all round, of more than an inch between their sides and those of the tubes. The tunnel-tubes are of cast iron in ordinary lengths, put together with leaded spigot and faucet joints, like common street mains. They pass beneath the yards of the station, and the streets, etc., having gradients nowhere quite level, and varying from one in one hundred to as much as one in eighty. These comprehend three important curves, two reverse to each other at Euston station, of 110 feet radius each, and one at the Post-Office at the remote end, of only forty feet radius. This was a local necessity, but has given an occasion of proving the flexibility with which these arrangements can adapt themselves to the sharp turns that must be encountered by any subways that conform to the streets of cities, and especially of old ones.

At Eversholt street terminal there is no apparatus of any sort, except that in a small building, obliged by local circumstances to be underground, there is found the open end of the tunnel tube, a pair of rails coming out of it across a small floor, and a buffer tube opposite, as already described.

The whole of the apparatus by which these carriages that are standing in the middle before us are transmitted hence to the Post-Office, and brought back thence again to where they stand, whether full or empty, is here in the building at Euston in which we stand. Of what does it consist? Turning our backs to the carriages we see a large, flat, round-topped casing, made of boiler plate, about twenty-two and one half feet wide by about four feet thick, at about four feet above the ground level. We observe that both sides of the casing are traversed by a strong wrought iron shaft, resting on plummer-blocks and cast iron framing, upon the front of which we recognize the stirring name of the makers, James Watt & Co., Soho.

This casing is that of the Pneumatic Ejector. This is the instrument by which air is put in motion either to propel the carriages forward from Euston, by blowing wind into the tunnel behind them, or *e converso*, by which they are drawn back from Eversholt street terminal, by producing a partial vacuum in the tunnel, into which the atmosphere at the remote end entering, drives the carriages on before it. The Pneumatic Ejector is a very peculiar form of centrifugal machine, the invention of Mr. Rammell, capable of performing all the functions, in the expulsion or exhaustion of air, to which the ordinary and well-known forms of revolving fan for producing blast are applicable, but with immense advantages in principle over those clumsy and noisy instruments, the reality and economy of which have been now practically demonstrated. We shall return to it presently. Passing behind the large bulk of this casing with its air-wheel of twenty-one feet diameter inside, we find a small high-pressure steam-engine, a single cylinder of fifteen inches diameter and sixteen inches length of stroke, upon inclined framing, and with its connecting-rod taking on to a crank-pin and crank, keyed directly on upon the end of the central shaft of the Pneumatic Ejector.

Alongside the engine is the boiler, an ordinary cylindrical one, with internal fire, and giving steam at forty pounds pressure to the engine.

This, with the arrangements for closing and opening the end of the tunnel here, after the dispatch, or on the arrival of the train of carriages, and those for enabling the ejector either to blow into, or draw out of, this end of the tunnel, constitute literally the whole apparatus—if we except the electric telegraph, by which communication between the terminals is kept up; and nothing gives to the mind of the practical engineer a more certain assurance of the future achievements that await this mode of transport and locomotion than the absolute simplicity of its parts, the paucity of detail, and the silence with which it works when in action.

A train of mail-bags is about to be sent down to the Post-Office, and the train directly returned, and for our especial information it is delayed a few moments, while, under the escort and with the running commentary of the inventor, we enter the casing of the pneumatic ejector by a door at one side, and make ourselves acquainted with its construction.

Within the casing, and well balanced upon its central shaft, which passes horizontally across from side to side, is a hollow circular disk of plate iron. The opposite sides of this disk are surfaces of revolution generated by curves, which are nearly hyperbolas, having a common asymptote at the axis, and terminating at the periphery almost in tangents parallel to the plane of revolution. At either side of the casing, at its central part, there rises up a cast iron air-trunk, having a united transverse area more than equal that of the tunnel, and whose outer extremities when united can, by means of throttle-valves and branch pipes, be placed either in communication with the open air, or with the interior of the tunnel (at this end) only. These air-trunks terminate at either side of the revolving disk in circular mouths of about three feet in diameter, to which corresponding mouths at the centre of the disk are adapted, and while the latter is free to revolve, are made air-tight at the circles of contact by means of an ordinary cup leather. The central shaft is fixed in the disk by radial rib feathers, and the curved sides of the disk are stiffened and connected by radial ribs. The width of the space at the periphery, between the sides or cheeks, is only about two inches. The property of the curve which determines the form is such that a circumferential section of the space between the cheeks is every distance from the centre the same, and equal to the area of the central indraft apertures just described. When rotation is given to the disk the whole plate of air within it is caused to revolve with it; and as in other centrifugal machines, the air is thrown off or out, all around the periphery, with a velocity proportionate to the deviating force, and its place supplied by other air drawn in at the central apertures round the shaft. The air delivered from the periphery is discharged into the casing, and from this, by arrangements of pipes and valves, it can be either *blown* into the tunnel—along the lateral branch extending some distance from the ejector—when the object is to *propel* the train before the wind, or the air being, in common language, *sucked* out of the tunnel, through the branch pipe, when the object is to *draw* the train back; the wind thus extracted is blown off into the open air by a passage provided beneath the floor, and on a level with the bottom of the ejector casing.

At the Euston entrance of the tunnel, after the train has been pushed into the interior, the end is closed by a light flap-door of plate iron.

This door is balanced and provided with detents, so arranged that it is opened automatically by the returning train about to debouch from the tunnel. The wheels in advance of the first carrige run over a pair of rollers, slightly projecting above the level of the rails, and mounted on the ends of two long levers. The roller-ends of these levers are depressed by the weight of the carriage, and these act on the detents and release the balance weights, which descend a few inches, and the door flies up and open an instant or two before the train makes its exit. A large adjustable valve, placed on top of the tunnel, gives the means, with perfect ease and certainty, of checking the incoming velocity of the train, so that in almost every instance the carriages come to rest within four or five yards of the same spot, and of the mouth of the tunnel.

Upon the occasion of our visit we saw a train run off to Eversholt street and return back in an interval of time that seemed incredibly short. The curve of forty feet radius obliges the reduction of speed a little at that point. Taking this into account, the actual working speed, through this bended and not favorably graded tube, is that of 520 yards in sixty-five seconds, or nearly sixteen and a half miles per hour. This is effected by a velocity of revolution of the ejector of about 100 to 110 per minute, which produces an atmospheric pressure of from three to four inches of water by the gauge, whether the air be moved in the one direction or the other, which is equivalent to about "a five-ounce gale," as the motive pressure is technically called by those in charge of the apparatus.

At the present time, about fifteen mails per day are transmitted forward and backward over the whole distance—being the whole traffic that the London and Northwestern Railway can supply to the District Post-office at Eversholt street.

From what has been stated as to the short time occupied in passing a train, it will be seen that the instrument is greatly more powerful than the demand here upon it, and that for a very large proportion of the whole time that steam has to be kept up during the day, the apparatus is actually idle, waiting for work; but even under this disadvantage, the consumption of fuel (coke, and a little coal) per day of ten hours, including getting up steam, amounts to but twenty-one bushels, and costs about six shillings, so that the charge for fuel is even now only about five-pence per double journey.

Arrangements are now in progress, we are informed, for extending the communication from Euston to the General Post-Office, and to several other district stations, when it is expected that the apparatus will be constantly, or nearly so, at work, and thus the cost of the aerial haulage reduced to a minimum, which will then obviously be a very small one.

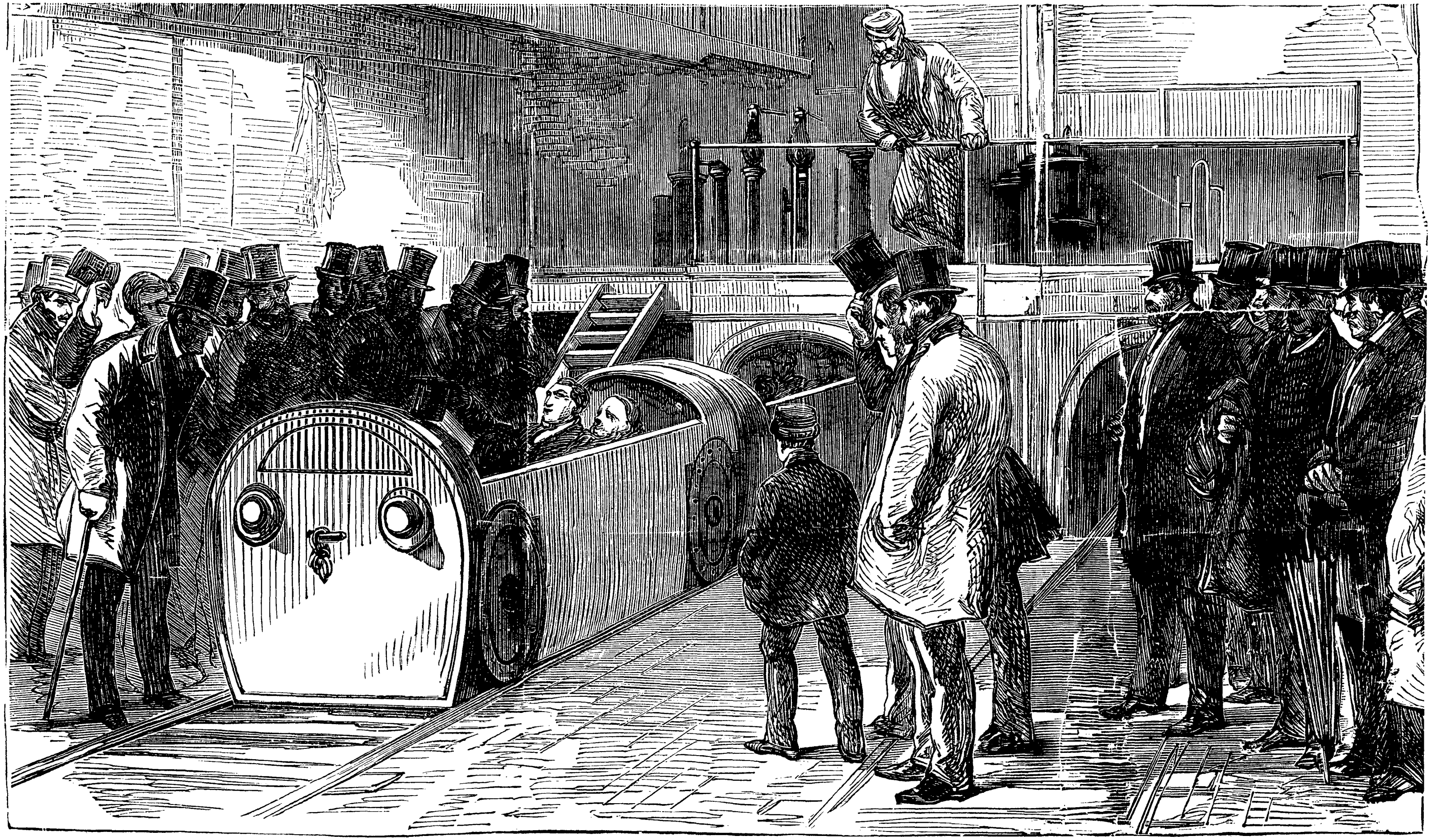


Fig. 2.—The London Pneumatic Dispatch—Inauguration of the Holborn Street Station.

OPENING OF THE HOLBORN EXTENSION OF THE PNEUMATIC DISPATCH, IN LONDON.

[From the London "Mechanics' Magazine," Oct. 13, 1865.]

PNEUMATIC DISPATCH RAILWAY.

THE works of the above line between Holborn and Euston Station are now completed, and the line ready for opening. To test the working of the company's tube, on Tuesday last, a small goods-train was driven through from the Central Station in Holborn, passing beneath Holborn, New Oxforn street, Tottenham Court road, Hampstead road, and Drummond street, on to the Euston Station, a distance of about two miles, having some sharp curves on approaching the North-Western Station. The tube is four feet six inches high, and about the same width, the rails being fixed in it for the carriage-wheels to run upon. At the Central Station, in Holborn, two tubes are carried beneath the footway and ground-floor of the building; one connecting Euston Station with the Central Station, and the other being intended to connect the latter with the Post-office in St. Martin's-le-Grand. This tube has only been carried to Holborn Hill. In the Holborn Station, the back portion of the building is occupied by three boilers, each of which can be worked up to a pressure of 30 lbs. per square inch. As a rule, only one boiler will be worked at a time, though all three can be used, if necessary. Between the boiler-room and the arrival and departure platform is the engine-room, fitted with two twenty-four horse-power engines, which work the shaft of the circular disk or fan, twenty-four feet in diameter. This, revolving rapidly upon its axis, having inclosed air-chambers, can be used either for propelling the laden trains forward by atmospheric pressure behind them, or for drawing them back through the tube by forming a partial vacuum before them.

The trucks of goods, accompanied by one of the attendants, were blown through the tube to Euston in about five minutes, showing the ease with which a portion of the goods and parcels traffic of the metropolis will shortly be conducted. Wheatstone's telegraphic apparatus is used at the stations, and is found to act well. In the station there are two main lines of rails and three sidings, the distance between the rails being three feet eight and a half inches. There are also two traversing platforms for shifting the trucks from one part of the station to another. The Duke of Buckingham, the chairman, and some of the directors of the company, were blown from the Holborn Station, under the supervision of Mr. Rammell, the engineer, through the tube to Euston, the distance being accomplished in five minutes.

OPENING OF THE EXTENSION OF THE PNEUMATIC DISPATCH IN LONDON.

(See Figure 2.)

[From "Frank Leslie's Illustrated Newspaper," Feb. 17, 1866.]

THE system of conveyance by atmospheric propulsion through a tube, which was lately exhibited in the grounds of the Crystal Palace, England, and had previously been tried on the short experimental line at Battersea, as well as in the neighborhood of the Euston Square Station, in Seymour street and Eversholt street, Camden Town, has now obtained an important practical extension by the opening of the line from Euston Square to Holborn, a distance of one mile and three quarters, whence it will be continued another mile eastward to the General Post-Office, St. Martin's-le-Grand.

The premises, No. 245 Holborn, which are the present terminus of the line, are well worthy of a visit of inspection.

Entering from the level of the street, the visitor passes along a corridor through a doorway, and emerges upon a gallery of considerable size, from which he looks down on a brick floor, supporting lines of rails, much as he might do from a railway platform down on to the line, but from a greater elevation. Underneath the corridor by which he has just entered he sees some mechanical appliances, suggestive partly of an engine-room and partly of a pointsman's gallery outside a railway station; and below the level, again, on which the white-jacketed engineer in charge is standing, and supporting the platform on which both he and these mechanical appliances rest, are a couple of openings, looking like black, polished modern chimney-pieces with the grates withdrawn. These are the mouths of the pneumatic tubes, of which one communicates with the North-Western Railway; the other, idle at present, will soon be drawing in and delivering mail-bags from and to the postal headquarters in London. The mouth of each tube is shut, when the tube is exhausted by air, by iron folding doors, which meet, not evenly, but at an angle projecting outward, so as to resist the atmospheric pressure from without. These doors are made to fly open on the approach of the train, the bolt which closes them being withdrawn by the action of a spring-lever, which underlies the rails, and gives way beneath the weight of the train. The carriages are shaped like a capital D turned over on its straight side and mounted upon wheels. Each end of the carriage has a raised hood, or flange, shaped so as to correspond with the interior of the tube, the dimensions of which are four feet in height by four feet six inches in width. Their ordinary freight is expected to be, in the first instance, letter-bags, then probably railway parcels, certain descriptions of market produce, and, ultimately, it may be, general merchandise.

On the opening day the Duke of Buckingham, Chairman of the Pneumatic Dispatch Company, had invited a number of scientific gentlemen to inspect the apparatus. After the train had made some successful passages to and fro, several of the party expressed a strong desire to pass through the tube themselves. They were warned that the line was "not constructed with a view to passenger traffic," and that they might find the way "a little rough." The spirit of adventure, however, prompted them to take this strange journey, and each of the wagons had soon as many occupants as it could comfortably accommodate in the recumbent posture enforced by circumstances. Tarpaulin coverings were obtained for one or two of the carriages, but the greater number of the excursionists had to fit themselves in as best they could among the bags of shingle which made up the temporary loading, taking care to keep their heads well below the edge of the carriages.

The air within the tube was by no means foul or disagreeable; here and there a strong flavor of rust was encountered; but this was explained by the fact that, as the tube had to be laid in lengths, through various soils, and encountered in the process a large share of unfavorable weather, the corrosion on the surface of the iron could not be expected wholly to disappear until cleared away by the friction of constantly passing and repassing trains.

On the arrival of the excursionists at the upper or Euston Square extremity of the line, they quitted their places for a few moments to inspect the smaller tube, which communicates with the Eversholt Street District Post-Office, and then returned by the way they had come to Holborn.

No doubt remained on the mind of any person who witnessed the opening trip as to the facilities which the system, if a sufficient number of stations can be incorporated with it, is calculated to afford, not only to the postal service, but to the requirements of the general public. The scheme of the company, who, it seems, possess under their act powers to lay down pneumatic tubes at any points within the jurisdiction of the Metropolitan Board of Works, is to construct similar lines to that now opened between the ten district post-offices and the General Post-Office, and between the different railway termini and goods-depots in London, connecting with these lines the six principal London markets and other important points.

For these purposes, it is calculated that some thirty-five miles of tubing will be required. The company expect that great profits will eventually accrue to them from the carriage of goods.

CHAPTER III.

THE EARLY ATMOSPHERIC PASSENGER RAILWAYS—OPENING OF THE FIRST PNEUMATIC PASSENGER RAILWAY AT SYDENHAM IN 1864—GREAT SUCCESS OF THE ROAD—PARTICULARS CONCERNING THE TUNNEL BLOWING MACHINERY, AND PASSENGER CAR—INCLINES EASILY ASCENDED STEEPER THAN THOSE OF ANY OTHER RAILROADS.

[From the London "Mechanics' Magazine," Sept., 1864.]

ATMOSPHERIC RAILWAYS.

EXACTLY fifty-four years ago, a Mr. Medhurst proposed that a brick tunnel should be built and applied to the conveyance of passengers, at speeds never more than dreamt of before. Within the brick tunnel a pair of rails were to be laid, and on these rails a suitable vehicle, very similar in its general arrangements to an ordinary railway carriage, was to travel. The cross section of the brick tube, as proposed, would have been egg-shaped, with the maximum width above. The rails would have rested on projections springing from the side walls near the bottom. To the rear of the carriage, a piston, so to speak, formed of boards suitably framed together, would have been affixed. This piston would have nearly fitted the tunnel. Whether any expedients were proposed by which the space between its edges and the brick-work could be made partially air-tight, we are not prepared to say. It is not likely that a scheme so perfect in principle as this was would be found wanting in detail. The carriage and piston thus provided, and put in place within the tube, air was to be forced in behind by means of a large pumping apparatus, very similar, we believe, in general design, to the blowing engines at present used at our iron-works.

The pressure of the air thus pumped in would, it was contended, prove sufficient to propel the carriage with its load of passengers at very high speed.

Medhurst lived before his time. The scheme never got beyond a model, for obvious reasons. In the first place, the steam-engine was not yet perfected, and the obtention of the necessary motive power for the blowing machinery was by no means easy. In the second place, people had a very great and perhaps natural antipathy to the idea of being placed within a tube, dark and cheerless, and blown to their destination; and thus a really valuable invention fell to the ground. It is easy, however, to see that Medhurst's was no ordinary mind. In this scheme we have the embodiment of nearly all that constitutes the modern railway; the iron rails, the high speeds, the accommodation for passengers, have a great deal in common

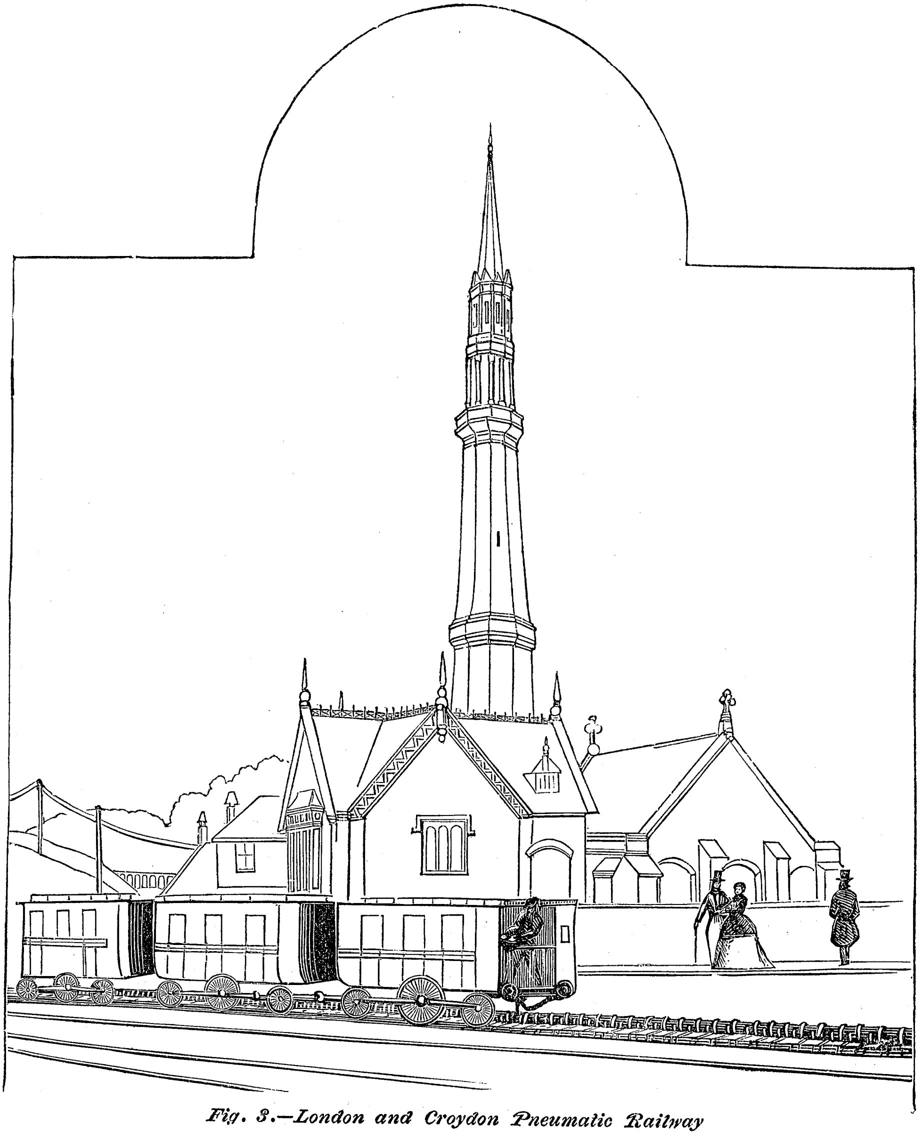


Fig. 3.—London and Croydon Pneumatic Railway

with the present system of locomotion, and all this, be it observed, was designed twenty years before the Rainhill trials inaugurated the railway system.

After Medhurst came Vallance and Pinkus, who had no better success than Medhurst, and it remained for Messrs. Clegg and Samuda, years afterward, to develop the system on a practical scale on the London and Croydon, and Dalkey and Kingstown Railways. (See Figure 3.)

The atmospheric principle as tried on these lines is now well known to be wholly unsuitable to the demands of an extensive traffic, and, as far as the country is concerned, the vacuum-tube and the piston-carriage have been banished forever in favor of the locomotive. With the introduction, however, of the underground metropolitan railway system, the old scheme of Medhurst bids fair to be revived. Indeed, there is hardly room to doubt that it is, of all others, the most suitable for the exigencies of this species of traffic. In the pneumatic dispatch we have, on a small scale, all that Medhurst proposed; and there can be no room to doubt, from the success which has already attended upon the labors of the company, known by the same name, that the system can be extended to the conveyance of passengers without any practical difficulty whatever.

During the last few months, too, Mr. Rammel, the inventor of the pneumatic dispatch scheme, has been laboring at the Crystal Palace to provide a model line, the first on which regular passengers have been conveyed, which would serve to bring all these advantages fairly before the public. (See Figure 4.) The tube extends from the Sydenham entrance, to the armory near Penge-gate, a distance of about a quarter of a mile, and it is, in fact, a simple brick tunnel, nine feet high and eight feet wide, a size that renders it capable of containing an ordinary Great Western Railway carriage. That actually working in the tube at this moment is handsome and commodious. The piston is rendered partially air-tight by the use of a fringe of bristles extending nearly to the brick-work of the tunnel and its floor. A fan twenty feet in diameter is employed to exhaust or to force in air, and perhaps it is impossible to devise any other expedient so well calculated to answer the required purpose. It must be remembered that either a pleuum or a vacuum equivalent to five tenths of an inch of mercury is quite sufficient to propel even a heavy train at a high speed on a moderately level line. In the present instance the motive power is supplied by an old locomotive borrowed from one of the railway companies, which is temporarily mounted on brick-work. The tires have been removed from the driving-wheels, and these last put the fan in motion by straps. The line, we have said, is a quarter of a mile long; a very small portion of it, if any, is level, but it has in it a gradient of one in fifteen, *an incline which no engineer would construct on an ordinary railroad;* and as it is not a level line, so it is not a straight one; for it has curves of *only eight chains radius*, which are shorter than those usually found in existing railways. The entire distance, six hundred yards, is traversed in about fifty seconds, with an atmospheric pressure of but two and a half ounces. The motion is of course easy and pleasant, and the ventilation ample, without being in any way excessive. All the mechanical arrangements are so simple and must be so obvious, we imagine, that it is needless to dwell on them. We feel tolerably certain that the day is not very distant when metropolitan railway traffic can be conducted on this principle with so much success, as far as popular liking goes, that the locomotive will be unknown on underground lines.

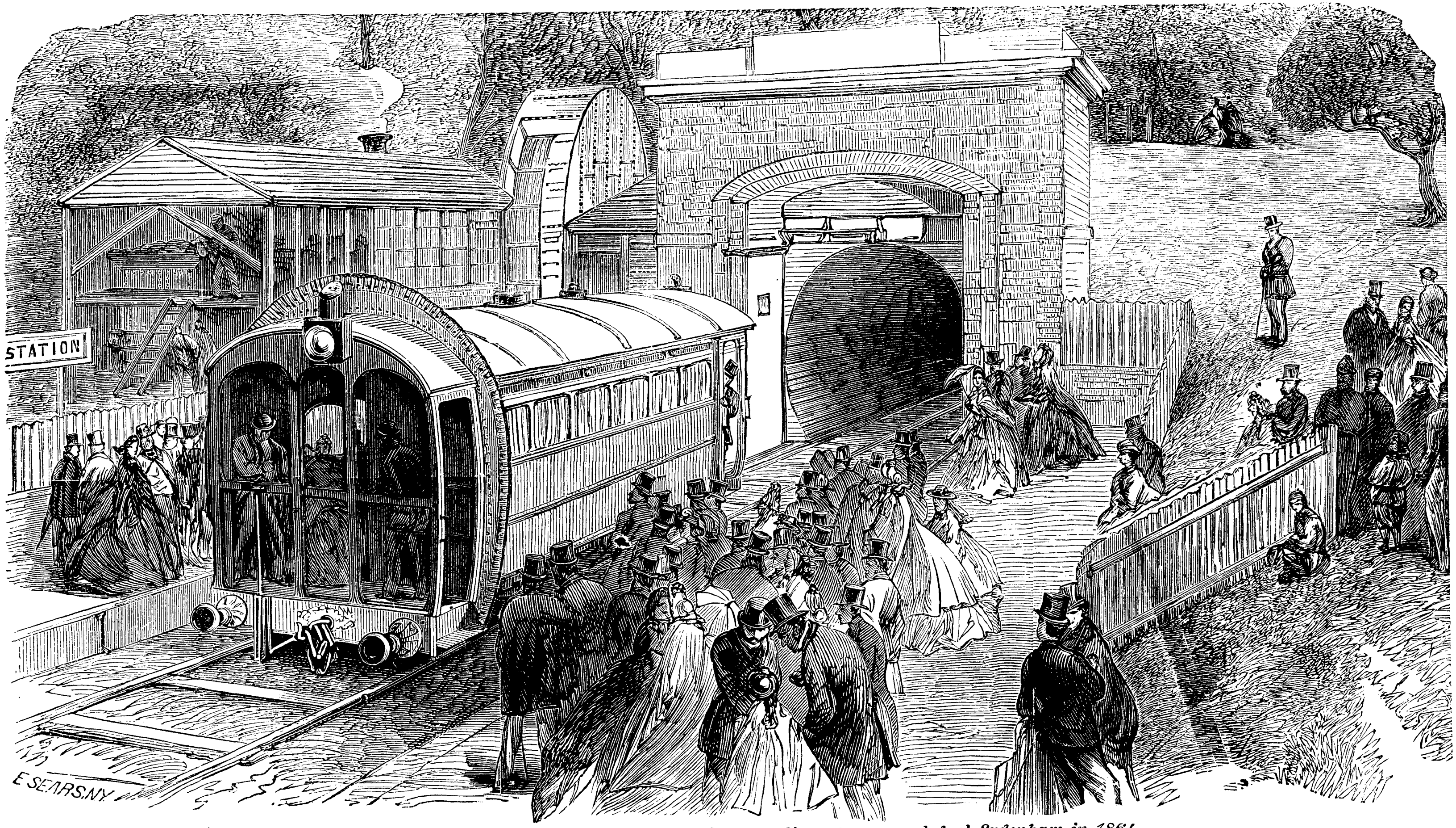


Fig. 4.—View of the First Pneumatic Passenger Car and Tunnel as operated at Sydenham in 1864.

THE PNEUMATIC RAILWAY IN THE GROUNDS OF THE CRYSTAL PALACE.

[From the London "Illustrated News," Sept. 10, 1864.]

WE give an illustration of the Pneumatic Railway, which has been put in operation during the last two weeks, in the grounds of the Crystal Palace. It extends from the Sydenham entrance to the armory, near the Penge-gate, a distance of nearly six hundred yards. A brick-work tunnel, about ten feet high by nine feet wide, and capable of admitting the largest carriages used on the Great Western Railway, has been laid with a single line of rails, fitted with opening and closing valves at each extremity, and supplied with all other apparatus for propelling passenger trains on this principle—by a strong draught of air behind the train when it travels in one direction, and pumping away the air in front of it when it travels the other way. The motive power is supplied by this contrivance: at the departure station a large fan-wheel, with an iron disk, concave in surface, and twenty-two feet in diameter, is made to revolve, by the aid of a small stationary engine, at such speed as may be required, the pressure of the air increasing, of course, according to the rapidity of the revolutions, and *thus generating the force necessary to send the heavy carriage up a steeper incline than is to be found upon any existing railway.* The disk gyrates in an iron case resembling that of a huge paddle-wheel; and from its broad periphery the particles of air stream off in strong currents. When driving the air into the upper end of the tunnel to propel the down-train, fresh quantities rush to the surface of the disk to supply the partial vacuum thus created; and on the other hand, when the disk is exhausting the air in the tunnel with the view of drawing back the up-train, the air rushes out in a perfect hurricane from the escape-valves of the disk case. When the down journey is to be performed, the breaks are taken off the wheels, and the carriage moves by its own momentum into the mouth of the tube, passing in its course over a deep air-well in the floor, covered with an iron grating. Up this opening a gust of wind is sent by the disk, when a valve, formed by a pair of iron doors, hung like lock-gates, immediately closes firmly over the entrance of the tunnel, confining the increasing atmospheric pressure between the valve and the rear of the carriage. The force being thus brought to bear upon the end of the train, the latter, shut up within the tube, glides smoothly along toward its destination, the revolving disk keeping up the motive power until it reaches the steep incline, whence its own momentum again suffices to carry it the rest of the distance. The return journey, on the contrary, is effected by the aid of the exhausting process. At a given signal the valve is opened, and the disk-wheel set to work in withdrawing the air from the tube. Near the upper end of the tube there is a large aperture, or side-vault, which forms the throat through which the air is exhaled, the iron doors at the upper terminus still being kept shut. In a second or two the train posted at the lower terminus, yielding to 'the exhausting process going on in its front, and urged by the ordinary pressure of the atmosphere from behind, moves off on its upward journey, and, rapidly ascending the incline, approaches the iron gates, which fly open to receive it, and it emerges at once into daylight. Instead of a train being used at Sydenham, there is one very long, roomy, and comfortable carriage, resembling an elongated omnibus, and capable of accommodating some thirty or thirty-five passengers. Passengers enter this carriage at each end, and the entrances are closed with sliding glass doors. Fixed behind the carriage there is a framework of the same form, and nearly the same dimensions, as the sectional area of the tunnel, and attached to the outer edge of this frame is a fringe of bristles forming a thick brush. As the carriage moves along through the tunnel, the brush comes into close contact with the arched brick-work, so as to prevent the escape of the air. With this elastic collar round it, the carriage forms a close-fitting piston, against which the propulsive force is directed. Although the curve in the tunnel is unusually sharp, being of eight chains radius, and the gradients are as high as one in fifteen, (those of Holborn Hill being only one in eighteen,) it is surprising that the motion is much steadier and pleasanter than ordinary railway traveling. The journey of six hundred yards is performed either way in about sixty seconds, with an atmospheric pressure of only two ounces and a half to the square inch; but a higher rate of speed, if desirable, can easily be obtained.

CHAPTER IV.

INCORPORATION OF THE WHITEHALL PNEUMATIC PASSENGER RAILWAY—THE RAILWAY TO EXTEND FROM CHARING CROSS UNDER THE THAMES RIVER TO THE SOUTH-WESTERN RAILWAY—DESCRIPTION OF THE UNDERGROUND TUNNEL—DETAILS AND VIEW OF ONE OF THE SUB-AQUEOUS PNEUMATIC TUBES—PECULIAR METHOD OF CONSTRUCTION AND LAYING OF THE TUBES—SECTIONAL VIEW OF THE THAMES RIVER EMBANKMENT, SHOWING PASSAGE UNDER IT OF THE PNEUMATIC RAILWAY TUBE—PNEUMATIC VS. LOCOMOTIVE RAILWAYS—PNEUMATIC RAILWAYS IN SWITZERLAND.

[From the London " Mechanics' Magazine," June 16, 1865.]

WHITEHALL PNEUMATIC RAILWAY.

When railways first began to invade London, they were met on the threshold by the prohibitory injunction, "Thus far and no farther." Not a foot might they advance beyond the suburbs, be the necessity what it might. The great point was to compel all railway companies to keep their termini at a respectful distance from the metropolis proper. The citizens' territory was to be sacredly protected against the intrusion of the iron horse, and the royal prophecy, that the map of London would one day be marked with railways as with a gridiron, was to have no fulfillment in fact. But matters have changed since those days, and there is now a growing conviction that the metropolis must be provided with railway accommodation throughout its length and breadth. The establishment of one line led to the construction of a second and a third; and for the birth of how many more during this session we may consider these responsible, we know not yet. But the construction and working of railways in the metropolis must be based upon principles differing widely in the main from those most familiar to us in other lines. In London railways can not be otherwise than a nuisance if overhead, on the ground-level, or in open cutting. Under any of these conditions they are open to many objections, and are in fact inadmissible. Their proper and only place must, therefore, be in tunnels, out of sight and hearing. The general conditions of construction being determined, it remains to decide the method of working. Now, it is certain that tunnels can never have proper ventilation, or passengers pure air, so long as the generation of steam is proceeded with upon the line. The fire-box of the locomotive must be sacrificed to begin with. To do this it has been proposed to use an engine containing the necessary volume of water, heated sufficiently to produce the requisite quantity of steam to work, for a given distance, without any combustion or generation of gases in the tunnel. But the boiler has yet to be made by which this idea shall be effectuated. Even were this accomplished, there would still be the highly objectionable waste steam blowing off into the atmosphere, saturating it with moisture, and condensing on the surface of the tunnel. But another engineer steps in, and recommends the waste steam to be blown into a cast iron pipe between the rails, and therein condensed. But while such plans are maturing, and pending the practical realization of these and similar ideas, let us see to what extent we can avail ourselves of other sources of power—how far we may travel independently of the direct action of fire and water, under conditions where, as sources of motion, they are clearly inadmissible.

It is an old notion, and by no means an erroneous one, that the power acquired by atmospheric pressure would realize greater safety, economy, and expedition than that obtained by the ordinary locomotive. The trial of the system of atmospheric propulsion for fourteen years, on the line from Paris to St. Germain, bears witness to the absolute security attending its adoption. We have also had practical experience in this direction on some of our own lines. But the system has failed, and this has been due to the imperfect manner in which it has been carried out. Notwithstanding all that was done to develop the principle, it had to be abandoned, not from any inherent fault or fundamental error in the principle itself, but because the details of its application were not sufficiently mastered to render it a practical success. To insure the effectual working of the atmospheric system, tunnels and a piston-carriage must be substituted for the old arrangement of tube and traveling-piston; such a system of working, for instance, as that in operation on the experimental line at the Crystal Palace. Here a power has been developed by which trains have ascended inclines inaccessible to the ordinary locomotive. This result is obtained from the pneumatic system which differs materially from the former atmospheric system. By the new method, the train is wholly within the tunnel or tube, by which arrangement all the difficulties attendant upon working the continuous valve are entirely overcome. Leakage is thereby avoided, and a considerable further advantage is obtained in working at reduced pressures, and with proportionate economy.

With the old arrangement, a pressure ranging from one hundred and twenty to one hundred and sixty ounces per square inch was required to move the train, but under the new conditions a pressure of not more than three or four ounces per square inch is all that is necessary. In the Crystal Palace tube, the train is moved through a tunnel having an area of eighty or ninety square feet, at the rate of thirty or forty miles per hour, by a pressure of only two and a half ounces on the square inch. This propulsion is simply due to the pressure of the air behind the train, so that, in effect, the pneumatic system is but a modified application of the process of sailing to railway trains. The practical utility of this system has been proved, not only by the successful working of the trial passenger railway at Sydenham, but also by that of the Pneumatic Dispatch Company. It is now to be further tested on a practical working scale, upon a railway about to be made from the Waterloo station across, or rather through, the bed of the Thames to Charing Cross. The bill for this line has not yet been obtained, it is true, but it has passed the House of Commons, and is unopposed in the Lords, so that for all practical purposes it may be acted upon as though it had received the royal assent.

The importance of this system of working railways, and the novel position of the line, justify somewhat more than a passing glance at the engineering arrangements, which will be carried out under the direction of Mr. T. W. Rammell, engineer to the Pneumatic Dispatch Company, and with whom Sir Charles Fox & Son are joint engineers. The new system affords great facility for communication under water. Taking advantage of this, it is proposed to lay a line of tube in the bed of the Thames, so as to unite the north and south sides of the river, between the two points embracing the important localities of the Charing Cross and the South-Western Railway stations. According to the Parliamentary plans, the line will commence in Great Scotland Yard, where there will be an open station, the level of rails being here about sixteen feet below surface. It will be carried thence by a brickwork tunnel under the Thames embankment to the river, which at this point is about one thousand feet wide. Here the line will be continued by water-tight wrought iron tube, about eighteen feet in diameter, which will be made of three fourth inch plate, and girt at about every thirty-six feet with a deep wrought iron rib, to which will be connected lighter longitudinal ribs, also of wrought iron. The tube will be further surrounded by light ribs of T or L iron, placed intermediately between the larger encircling ribs, the whole forming a stiff network to strengthen and stay the tube. The outer surface of the tube will be coated to the thickness of eighteen inches with concrete, for the purpose of adding weight to the tube. By this plan it will be brought to about the specific gravity of the surrounding water, and the ironwork will also be protected. The bed of the river will be divided into four spans, of two hundred and fifty feet each, by means of three sunk cylinder piers; there will also be two abutment piers. These piers will carry the tube, which is about to be manufactured in four lengths, of two hundred and fifty feet each. A perfectly practical and satisfactory arrangement has been made for connecting the ends of the tubes, which will be tied down to the piers. Messrs. Samuda have undertaken the manufacture of the tube, and to Messrs. Brassey have been entrusted the laying and other incidental works. From the abutment pier on the Lambeth side the line will be continued in brickwork under College street and Vine street, to a station convenient for the York road and Waterloo station traffic. The gradients fall from either station to the centre of the river, at which point the line is level for a short distance; the steepest gradient will be about one in thirty.

It will be seen that the line is intended for local traffic only, and it is proposed, upon the success of the first section being established, to extend the line on the one hand to the Tottenham Court road, and on the other to the Elephant and Castle. This will add ten-fold to the value of the line, by bringing it into close communication with the Metropolitan Underground Railway at one end, and the Metropolitan Extension of the London, Chatham, and Dover Railway at the other. The engine-house will adjoin the station at the Waterloo end, where will be placed the pumping-engine for working the line. Although only one main tube is to be used, arrangements have been made by which three trains will be kept working at once.

One will be at each station unloading or loading while the third is traversing the line, the time of transit occupying only about a minute and a half. By means of two branch tubes from the main tube to the engine, trains will be driven by pressure to Whitehall, and drawn from thence by exhaustion. The carriages will, of course, be properly lighted and comfortably fitted, similarly to those on the Metropolitan Railway. It is reckoned that about thirty trains per hour will be run, and, from calculations based upon well-ascertained data, there appears to be every probability that the undertaking will prove a commercial as well as an engineering success.

It can not be questioned that the pneumatic system possesses many advantages over the locomotive system, which specially recommend its adoption on the Waterloo and Whitehall Railway. If this line proves a success, and at present there appears no reason why it should not, the system will, doubtless, receive a very widely-extended application. It presents economical features, both in construction and working, not obtainable by any other plan. The diameter of the pneumatic tube being less than that of a railway tunnel, the lines can be constructed with greater expedition and at a less cost. The heavy expenses attending the acquirement of property are greatly reduced, if not entirely avoided. In the case of the Whitehall line the construction will not involve the demolition of a single dwelling-house, the entire line passing under streets and open spaces. The working of the system, too, is comparatively noiseless; this, and the freedom from vibration, recommend its use where a locomotive line would be prohibited. The dead weight and encumbrance of the engine and tender are at once got rid of, and the service thus rendered more prompt and better adapted to the exigencies of a short local traffic. All the dangers attending the locomotive system, arising from breaking down, collision, or explosion, are necessarily absent; trains can neither leave the rails nor meet within the tube. The system also complies with the conditions laid down as those under which alone tunnel lines ought to be worked. It is unattended by the objectionable compound of stifling and humid vapors which Mr. Fowler's best precautions can not entirely prevent on the Metropolitan Railway. Not only is the generation of gases avoided, but the tunnel is completely ventilated by the continuous draught of air through it. The motive power being stationary, the working expenses and cost of maintenance of the line will be very much less than under the ordinary system; the wear and tear of rolling stock may likewise be reduced to a minimum. The facility with which steep gradients and sharp curves can be worked is evinced by the Crystal Palace tube, which is constructed with a gradient of 1 in 15, and curves of 8 chains radius; on the Whitehall line the worst gradient is about 1 in 30. Such, then, are the leading advantages of the pneumatic system, the working of which is about to receive practical illustration in a position where there are doubtless thousands daily, who would much prefer being whisked across in a minute and a half, for a penny or twopence—which we believe are the proposed fares—to making a long detour over either of the bridges. Deducting the halfpenny toll payable on Waterloo and Hungerford bridges practically reduces the fares to a halfpenny and three halfpence respectively. Although the engineering details have been well digested and worked out, and every care has been taken to perfect the arrangements, it may be found advisable to vary or alter these as the work of practical construction proceeds under these novel conditions. But the principle will remain the same, and to it we look with considerable hope for the future working of short lines for local traffic in the metropolis.

[From the London Correspondence of "New-York Herald" of 5th of February, 1865.]

THE PNEUMATIC DISPATCH—LOCOMOTIVE POWER.

Considerable attention is now being paid to the best means of carrying on the enormous passenger and goods traffic of London. The conclusions almost universally arrived at are, that the great bulk of it must be done by pneumatic propulsion. Recent scientific experiments have demonstrated that the locomotive uses less than one tenth of its power in railways that have as frequent stoppings as necessary in a city like London. It is wasted in the friction caused by overcoming the inertia of starting the trains and getting up the speed, and then in stopping. A train ordinarily, on a long line, can not get fairly up to its normal speed without running from a mile and a half to four miles, while in or under cities they must stop every third or half of a mile. In a very elaborate and interesting paper, read before the Society of Arts last week, it was demonstrated, or at least stated, that in a locomotive power of twenty-two hundred horses, on city railways, the power actually used in propelling the train was only that of two hundred and fourteen horses. The paper was not on the subject of the pneumatic power, but on power generally for the purposes of city traffic. But the great loss of power attending the use of locomotives was illustrated in pneumatic propulsion. In the locomotive, the train is drawn by the friction, or "bite," of the wheels of the engine on the rails. But in the pneumatic propulsion, where the air is the motor, it may be said, by a mythological figure, that Æolus, the God of the Winds, draws the trains, or pushes them, by his ethereal breath, while on the wing, with no foothold on the earth whatever, and none required. The Metropolitan (underground) Railway, from Paddington to the city—some three miles long—now carries sixty-four thousand passengers daily—a line about as long as from the South Ferry to Madison Square, up Broadway. The receipts of this short railway are now £2600 ($13,000) weekly, or about £150,000—say $750,000, gold, annually. But the traffic is not yet anywhere developed. The line stops at least a mile and a quarter from the Bank and Royal Exchange, and runs over a route that is neither a great thoroughfare nor that contains a large resident population. A bill is coming before Parliament to make a line across the river—tunneling the Thames again—near the Houses of Parliament, from the proximity of Charing Cross to the Waterloo Station—the terminus of the South-Western Railway—running to Southampton. This is for a pneumatic line. At Liverpool they are agitating the tunneling of the Mersey. So, after an uninterrupted and prosperous reign of nearly forty years, that useful servant, the locomotive, or "steam-horse," stands some chance of being superseded by a more powerful motive monarch. It will not be the first time that a reigning sovereign, on growing old, has had to give way before a younger and more vigorous aspirant and rival. Science will never be stopped in her onward progress, no matter what interests get crushed by her powerful wheels.

THE SUB-AQUEOUS PNEUMATIC DISPATCH—WHITEHALL PNEUMATIC RAILWAY.

One of the new passenger lines on the Pneumatic Dispatch plan, now being laid down in London, is to extend underneath the river Thames. The river is to be passed by means of wrought iron tubes, thirteen feet in diameter, covered with brickwork, and made in sections of 221 feet each. The tubes are built upon stocks and launched like a ship, floated over the place where they are to rest and then submerged. We herewith present an engraving of one of these tubes, from a photographic view, as it appeared a few weeks ago, except the brickwork, which had not then been put on. Through this tube any of the ordinary English railway cars can be driven by atmospheric pressure. The *Scientific American* of February 16th, 1867, in an interesting article upon Bridges and Tunnels, thus speaks of the work above mentioned:

"Some of the expedients proposed by English and American engineers for locating tubular tunnels under water may here be mentioned. The first in prominence, at present, is the plan adopted for sub-tubing the Thames in London. The tube of the Waterloo and Whitehall Pneumatic Railway is to be built in four sections or spans of 221 feet each, supported not merely along the length of the tube in a dredged channel, but also upon piers going down to the clay. The tubes, now in course of construction by Messrs. Samuda, at the Isle of Dogs, are of three quarter inch iron, with three rings of enveloping brickwork bound by hoops of angle iron, and are to receive, after being laid, an internal lining of brickwork, bringing their diameter to

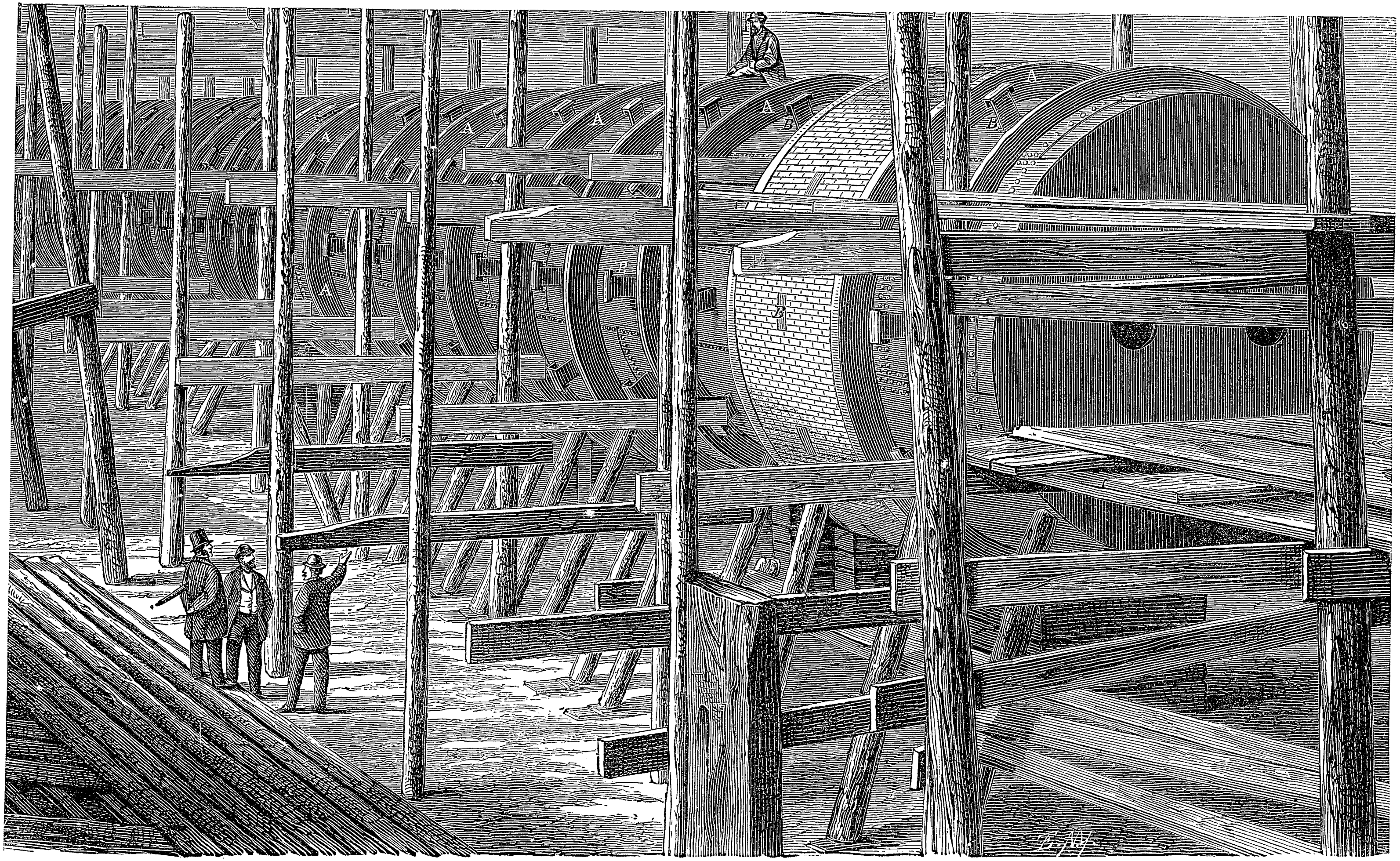


Fig. 5.—Whitehall Pneumatic Railway.—The Pneumatic Section of the Thames River Tube, prior to Launching. (From a Photograph)

twelve feet nine inches. The length of the tubes, including shore ends, will be five eighths of a mile. The ends of each section are closed by bulkheads, and when finished all will be floated down to Hungerford, and by a moderate admission of water will be eased down into exact position in the trench and on the foundations prepared for them. The ends will be brought into connection as lowered, by means, we presume, of guiding rods on the one entering corresponding holes on the other, and a close joint will be effected 'by means of an ingenious water-tight lock or stuffing-box, devised by Mr. Rammell.' From which language of our English authority on that point (*Engineering*) we understand that the ends are to interlock, with suitable packing, in some way that will result in a water-tight joint for purposes of construction. It is evident that a packed joint could be forced home, without any required power, by the simple exhaustion of air from the shoreward section. The bulkheads can then be removed, and the joint secured and packed permanently, by means of inside flanges, ready bored with matched bolt-holes. Indeed, supposing the nearer flange to be inside the bulkhead, and the holes in the opposite flange to be threaded, the bolts might be inserted through without removing the bulkhead, if thought necessary or more prudent. Then, cutting away the bulkhead, the annular space between the flanges could be packed impenetrably, at leisure, or, if needful, in haste.

"This is very likely the simplest and least expensive mode of joining the tubes at moderate depths. Others, however, have been suggested, and we shall mention last a suggestion of much promise for sub-tubing the Straits of Dover. Such things have been proposed and discussed since as long ago as 1809. Half a century is not an excessive period to elapse between the first suggestion of a great improvement and the first serious attempt to realize it. One of the best plans offered in the past was to build a wooden coffer-dam for a section of the work, by one of the variety of methods in use; commencing at the shore, and having either excavated and lined with masonry a tunnel in the river bed, or laid a tube of wrought or cast iron, or wood, and fully imbedded it in loose rock and earth, then cross the dam with a bulkhead, or new end near the termination of the finished work, and thence—removing the portion now done with—extend the dam forward to inclose a new section of the work to be done. This, being substantially a well-tried system, and affording clear space and leisure for the most thorough foundations, superstructure, and leveling, will commend itself to careful consideration; especially if the danger of forming a bar in the harbor should compel the constructor to sink his work wholly beneath the bed of the river."

[From the London "Mechanics' Magazine," November 17, 1865.]

PNEUMATIC VERSUS LOCOMOTIVE RAILWAYS.

The accomplishment of the longest distance in the shortest time is the great mechanical problem of the present age, which theoretically aims at the virtual annihilation of time and space, whether relating to the transit of words, materials, or individuals. With respect to the first of these, the electric telegraph has not only theoretically, but we may even say practically, accomplished the solution of the problem. The steps made toward accelerating the transit of the second and third are measured by the average maximum speed attainable on our railways by the goods and passenger trains. For some years back there has literally been no progress made on our railways. By progress we do not mean the mere extension of the railway system, or the multiplication of lines over the kingdom, and, in fact, over the whole world in general, but that increase of speed which we are now entitled to expect, should have taken place since the introduction of railways, but which certainly has not. When Stephenson, in the first competitive trial of locomotives, carried off the prize of £500 with the "Rocket," he drove it for a portion of the way at the rate of twenty-five miles an hour; and every railway traveler is well aware that the ordinary passenger trains do not even reach this.

It is evident, with respect to the speed attainable on our railways, that we now, and for some time past, have reached a climax, and are precisely in the same comparative position as the old mail coaches, when they reached a speed of about eight or nine miles an hour. There they stopped, and there they would have stopped until the end of time. So it is with our railways. A certain speed has been reached—say, a maximum of fifty miles an hour and no more. Nor will a higher velocity be obtained on our present lines, or on any others constructed in a similar manner, and on what now seems to be the orthodox principle, which entails the adoption of sharp curves and steep inclines as an indispensable accompaniment of railway construction. It is not that the necessary motive power could not be obtained, for, leaving out of consideration the enormous expenditure and the questionable nature of the advantages attendant on a large increase of locomotive power, any degree of speed might be produced, but the manner in which our lines are constructed does not admit of more than a certain speed consistent with safety. That speed has been already attained, and it is in vain to suppose that a higher one can be reached on any line constructed on the present system. If, then, the locomotive principle is to be adhered to in our future railways, the roads themselves must be altered before that degree of speed is attainable which will, before long, be demanded by the exigencies of modern advancement. It is worthy of remark that when railways superseded the mail coaches, the first operation necessary, before the improved method of locomotion could be introduced, was the alteration of the road on which the locomotion was to be conducted. We do not at present propose to enter on a subject so vast and comprehensive as the alteration of our present railways, in order to afford the desired velocity. There is another principle, namely, the pneumatic, which, although only on its trial, gives fair promise of supplying the above desideratum. The experiments made last year at the Crystal Palace have demonstrated, beyond a doubt, that it is possible, in an engineering point of view, to apply the principle to passenger traffic. Nor will the cost be found to be so excessive as is generally imagined. The first item, and often the most serious in the construction of a railway, is the purchase of the land. This item is reduced to a minimum in a railway on the above principle, firstly, because it is a continuous tunnel or tube, (although necessarily underground,) and, secondly, because it admits of very steep inclines, which would have the effect of reducing the cuttings and embankments to very insignificant dimensions, and cause the line to approximate more to a surface line. It is not at first apparent why the pneumatic admits of curves which could not obtain on the locomotive lines, for the resistance to be overcome is the same. It is because, on the latter principle, the whole motive power is directly affected by the construction of the road, whereas on the former it is altogether independent of it. A locomotive consumes a large amount of its power in moving itself, the expenditure of which increases rapidly in proportion to the gradients and curves. Leaving out of consideration the difference in expense between stationary and locomotive engines, the adoption of the former will yet considerably reduce the cost of the permanent way. It is asserted by the managers of iron-works that every additional order they receive for rails is for a heavier description than the preceding ones.

Rails of 80 lbs. and 90 lbs. to the yard are the only weights which will stand the terrific pounding of the driving-wheels of an express engine, while others of 50 lbs. and 60 lbs. would be sufficiently heavy for the traffic of carriages and wagons alone, and last very much longer.

In comparing the first cost of the two principles, we have thus at the outset a direct saving, in favor of the pneumatic, respecting the important items of land, earth-work, rolling-stock, and permanent way, items which are common to both. Against this, however, must be set the cost of the peculiar construction of the pneumatic railway, of which the heaviest portion is the tunnel or tube in which the carriages are conveyed. On the supposition that the tube would be made of brickwork, the cost would not exceed that of those portions of the metropolitan line which are continuous tunnels. It is probable that it would fall within this amount, as, in consequence of the locomotive being dispensed with, less headway would suffice, and thus the sectional area of the whole tunnel would be reduced, and a corresponding saving effected in the quantity of material employed. In the experimental trial at the Crystal Palace, quoted above, a headway at the crown of the tunnel of ten feet allowed the largest carriages on the Great Western line to pass. The least headway allowed on the South-Eastern Railway, from level of rails to soffit of crown of any arch, is thirteen feet six inches, or about one third more. On the other hand, it is questionable whether an iron cylindrical tube would not form the best inclosing medium. It would possess decided advantages when the line crossed a river, supposing circumstances did not permit of its passing under the surface of the water, for, being made additionally strong, it would serve the purpose of a bridge, not only in this particular instance, but wherever any intervening space is required to be spanned. There is no necessity for the tube being continually underground, as might be supposed, judging from the short pieces of line constructed. In fact, it would be impossible that it should be so in applying the principle to railways in general. The most advantageous cross-section of road would probably be a cutting just deep enough to cover the tube all over, and so protect it from the influences of the weather. We have before stated that, in consequence of the motive power on the pneumatic principle being unaffected by the resistances of the road, it will be able to afford a velocity greater than our present railroads can give. It must not, however, be inferred from this, that steep inclines and sharp curves are of no consequence on a pneumatic railway; for, no matter what the motive power may be, they virtually put a limit, and a most effectual one, to the speed which may be ultimately acquired. This principle will soon be applied to a passenger line, the construction of the Waterloo and Whitehall Railway having been recently commenced. The promoters, however, should bear in mind that, unless the new railway gives the public something which the present ones do not, there is no valid reason for supposing that, when the novelty has once worn off, it will have any advantage over those now in existence. Next to a lower fare from one place to another, there is nothing the public appreciate more than being able to travel by the quickest way, and, in truth, the quickest way, although it may in some cases be the dearest, provided the difference be not too great, pays the best in the long run. Many a railway has been irremediably spoilt, and the dividends reduced almost to *nil*, by too great a parsimony in the first cost. It is considered by some a clever piece of financial policy to keep the first cost low by introducing heavy gradients to lighten the expense of deep cuttings and embankments, and sharp curves to avoid the purchase of houses and other property. When, however, the profits of the line are swallowed up by the expenses attending the working of these inclines and curves, and the cost for additional repairs of the rolling

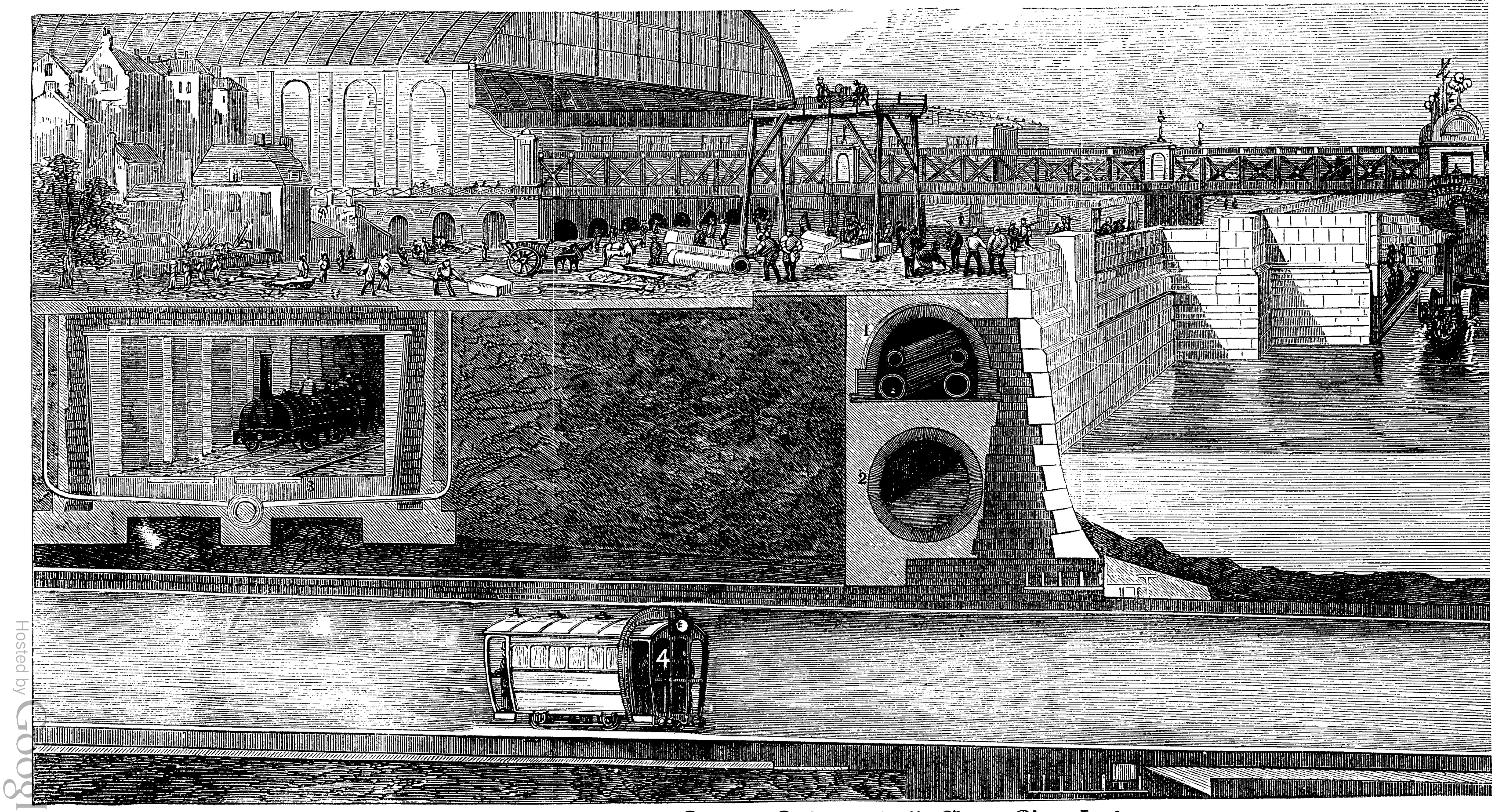


Fig. 6.—Section of the Pneumatic Passenger Railway under the Thames River, London.

(1.) Subway for Gas and Water Pipes. (2.) Sewer. (3.) Metropolitan Underground Steam Railway. (4.) Pneumatic Passenger Railway, now in course of construction. The Pneumatic Railway extends from Charing Cross, and passes under the Thames River to the Waterloo Road Station of the Southwestern Railway The engraving represents that portion under the Thames embankment which has been finished.

stock and permanent way, the error becomes apparent, and the fallacy of such parsimonious calculations but too evident. In the construction of a railway; like every thing else, the best way is the cheapest in the end, and it is to be hoped that the promoters of the pneumatic passenger railway will have a due regard to this fact when laying out their first line, and not ultimately incapacitate themselves from developing a high velocity by any inherent fault in the construction of their roads, which is unfortunately the case with nearly all our present lines.

[From the "Scientific American," June 22, 1867.]

PNEUMATIC RAILWAYS IN SWITZERLAND.

M. C. BERGERON, Director of the Western Swiss Railways, has obtained a concession from the Canton de Vaud to connect the railway station and the Place St. François, at Lausanne, Switzerland, by means of a pneumatic railway.

The same engineer has lately presented to the British Association at Nottingham the plans for a pneumatic railroad over the Alps, by the Simplon Pass, commencing in the Saltine Valley on the Swiss side, and the Diveria Valley on the Italian side. The distance is sixteen miles. M. Bergeron estimates the total expense at $4,000,000. The incline on the Italian side would be 1 in 14; on the Swiss side, 1 in 6¼. He proposes a tube large enough to receive carriages of the size of an ordinary omnibus. The highest point to be reached is 6000 feet above the level of the sea. The tube is to be cut in the form of a gallery in the side of the precipices, the debris being allowed to fall into the torrent below. The air current is to be produced by means of water-wheels, for which the streams furnish an abundant power. This is by far the cheapest plan yet presented for effecting the passage of the Alps by railroad. Its economy is principally due to the small area of the proposed tunnel. The working expenses would be very light.

CHAPTER V.

THE PNEUMATIC DISPATCH IN THE UNITED STATES—PUBLIC TRIAL OF THE FIRST PNEUMATIC RAILWAY AT THE AMERICAN INSTITUTE—MANY THOUSANDS OF PASSENGERS CARRIED—PARTICULARS OF THE CONSTRUCTION—FIRST PUBLIC EXHIBITION OF THE PNEUMATIC POSTAL DISPATCH—SUCCESS OF THE AMERICAN IMPROVEMENTS FOR COLLECTING THE MAILS—PROPOSED PNEUMATIC RAILWAYS—HEATING AND VENTILATING THE CARS—ELEVATED PNEUMATIC RAILWAYS—DETAILS FOR THE COLLECTION AND DELIVERY OF THE MAILS WITH GREAT EXPEDITION BY MEANS OF THE PNEUMATIC SYSTEM.

[From the "New-York Times," September 16, 1867.]

THE PNEUMATIC RAILWAY AT THE AMERICAN INSTITUTE.

IT would be indeed surprising if the inventive genius of this country had continued to sleep while the progressive labors above detailed were going on in England. The matter of underground railroads has been twice before the Legislature of this State, and last year two bills were presented, asking for the right to form a company, and the necessary charter to enable it to run pneumatic tubes for mail-dispatching purposes through this city. These bills, like many others, died a premature death in Albany, but with them did not die all hope in a successful future for the Pneumatists—if we may coin a short name for them for convenience' sake. Charters were obtained in Massachusetts, Connecticut, New-Jersey, and Pennsylvania, and it is understood that two bills for New-York will be again presented, with best guarantees of success, at the next session of the Legislature. In the meantime our spirited neighbor, Mr. Alfred E. Beach, of the *Scientific American*, is the first in the field with his demonstration of the practicability of pneumatic passenger locomotion, made on an actual working scale. The splendid example of a pneumatic railroad now erected at the American Institute Fair, and which will be in operation to-day, is the project of that gentleman, and it is not too much to expect that this enterprise will be duly appreciated, and in time rewarded.

In the construction of this great working model there are some peculiar features which will call for explanation as we proceed in the description of the construction as a whole. Besides the great tube for experimental passenger conveyance, there is a full-sized model of a Pneumatic Dispatch with noticeable improvements, which we shall also have to notice in this article.

The tube of the passenger railway at the Fair is suspended along the wall, and runs from gallery to gallery, a distance of one hundred and seven feet. It is six feet in diameter and is constructed of wood. The shell is but one and a half inches thick, yet it is claimed to be capable of immense resistance. This peculiarity is obtained by a novel process patented some time since by J. K. Mayo. The inch and a half in thickness is made up of fifteen layers, or lamina, of veneer, laid upon each other transversely and spirally, and joined together by cement. The grain of the woods thus crossed and recrossed gives a structure of remarkable strength and power of resistance to either blow or pressure. The carriage for passenger conveyance is long enough to seat on either side, like the ordinary street-car, ten persons. It is open at the top and sides, the latter rising sufficiently high only to protect the passengers' backs from friction against the sides of the tube. The door is placed in the centre of the O-shaped end which forms the valve or piston when the door is closed. The wheels of the car, four in number, rest on rails laid along the bottom of the tube, and project through the bottom a few inches only, being all that is necessary. The wheel attachments, and, with this exception, the wheels themselves, are immediately beneath the seats. This permits full use of the space within the tube, so that the carriage is just as free from touching the bottom as the sides. The motive power, placed at the northern end of the tube, consists of a great fan, ten feet in diameter, inclosed in a wooden chamber which forms one end of the tube. This fan is unlike any yet used. It is, in fact, a screw propeller with eight blades, so constructed that the pitch of the blades is not more than twelve inches. This fan is driven by an engine placed near by, and will make, if necessary, two hundred revolutions per minute. Turning in one direction it produces a vacuum by exhausting the air from the tube and throwing it off through apertures in the chamber, thus drawing the car at the other end rapidly toward it. When its motion is reversed, the opposite result is of course produced; the volume of air then taken from the surrounding atmosphere is poured in a resistless stream against the piston or flange of the car, which flies before it back to its starting place.

THE PNEUMATIC POSTAL DISPATCH.

Mr. Alfred E. Beach also exhibits at the Fair a section of a postal dispatch through which a truck for the conveyance of mail-matter is drawn or propelled in the same manner as above explained. A smaller fan is used for this tube. The tube itself is square, as are the trucks which pass through it. In connection with this apparatus is an ingenious automatic arrangement showing how mail-matter, received at different post-office depots along the route, may be kept separate and so delivered, and in like manner can a correct delivery at each station of out-going mails be effected. This is possibly the most interesting feature of this most attractive exhibition. (See Fig. 8.) The lamp-post rising from the middle of the tube represents a street depository, having in its base a pair of rotary letter-boxes. Every time the car passes the letter-boxes one of these is turned, and its contents drop into the passing car; when the car returns the other box is operated and its contents collected in like manner. Thus, the car when passing up-town collects all letters destined in that direction, having been dropped into the receiver of the lamp-post; returning, the down-town letters are collected from their particular box, into which they have been dropped advisedly from above.

PROJECTS.

On the success of these practical tests, under the auspices of the American Institute, no doubt will depend in a measure whether we shall have any immediate realization of the several projects in view, including not only the establishment of passenger traffic and the transportation of mail-matter, but the scarcely less gigantic one of sub-tubing the North and East rivers, and thus uniting Jersey City and Brooklyn with New-York.

It is estimated that the actual expense of laying down pneumatic passenger tubes under the streets of the city in the best manner with iron tubing, including the running stock and engines, would not exceed $100 per running foot, or $500,000 per mile, being much below the estimated cost of an under-ground steam-car railroad. The pneumatic plan would, doubtless, require a smaller tube than any other form, and, consequently, less excavation would be required; and, since by actual experience it is shown that it can describe the sharpest curve, the route would not be difficult of selection. The suspension of the tube at the fair illustrates the practicability of an elevated road, and suggests that the tube might be readily placed on posts or on brackets projecting from the houses passing between the blocks, or even running over the house-tops.

The estimated cost of laying down the pneumatic passenger railroad tube under the East River is $200 per running foot. Estimating the distance at three thousand feet, this would give an outlay of $600,000. Assuming this to be correct, the contrast between this sum and the $7,000,000 which the great suspension bridge is to cost is startling. For the larger sum it is claimed that a dozen or more pneumatic tubes could be laid down, affording ample trans-river accommodation at every important point on either river, connecting all the great leading thoroughfares of the sister cities.

It is further estimated that passengers by a through city tube could be carried from the City Hall to Madison Square in five minutes, to Central Park in eight minutes, to Harlem and Manhattanville in fourteen minutes, to Washington Heights in twenty minutes, and by sub-river to Jersey City or Hoboken in five minutes, and to the City Hall, Brooklyn, in two minutes. And that this, if ever accomplished—which is by no means improbable—ought to be done at rates of conveyance far below those now charged for most uncomfortable transportation, it is only fair to conclude from the comparatively limited outlay of construction anticipated.

The projected Pneumatic Postal Dispatch is of a very important and comprehensive character. It is proposed to carry a pneumatic tube of about two or three feet in diameter from the Post-Office up Broadway to Forty-second street, with branches at Twenty-seventh street to the Harlem and New-Haven railroads, and a branch at Thirtieth street to the Hudson River Railroad. A tube is also to girdle the city, passing through South and Washington streets, so as to touch all the ferries and such landings where mails arrive and depart, bringing these points into immediate communication with the General Post-Office. Tubes are also to extend through Chatham street, Bowery, and Third avenue, also along Broad, Pearl, Canal, Grand, Bleecker, and Fourteenth streets, and wherever the public requirements may need; all the sub-post-offices, of course, being connected with the General Post-Office. Further, it is proposed to extend the postal tube under the East River, or over the suspension bridge, if constructed, to Brooklyn, and through the principal streets of that city; also under the North River to Jersey City, where it will connect with the Pneumatic Dispatch Company of New-Jersey, to whom, as before stated, a charter has already been granted. By this company it is proposed to extend their lines as soon as possible to the nearest important cities, probably Newark and Elizabeth. By means of such a network, no doubt the mails of the suburbs and suburban cities would be delivered at headquarters with great rapidity. The postal cars, it is stated, could be run at the rate of thirty miles per hour, including all delays at intermediate stations. Thus, letters might be sent up-town as high as Forty-second street, and replies received, almost with the speed of telegraphic messages. The advantages to business men could not be over-estimated, assuming the successful operation of such a project. At the present time we know that letters in many cases must be deposited ten or twelve hours up-town prior to the mail-closing hour down-town, so as to secure transmission by that mail. Letters for the early mails must be deposited on the night before, or they fail to go, and to send a letter up-town and expect an answer on the same day would be to hope against hope. In this connection it is only necessary to say that, in whatever respect a pneumatic dispatch would be of value as a mail-bearer, it would also be valuable as a bearer of packages, and not by any means its least important business would be the delivery of newspapers at the various depots for the sale of that most valued necessity and luxury *juncto in uno.*

Leaving to the imaginations of our accomplished readers the pleasant labor of converting, with all the material here afforded them, our confused and crowded city, with its no less crowded water boundaries, into a terrestrial paradise, where easy locomotion on land, on water, beneath them both, or in the air, can be enjoyed at will, we close this article, hoping, with them, that out of this great field of promise we may some day soon pluck flowers of comfort.

[From "Frank Leslie's Illustrated Newspaper," Oct. 26, 1867.]

THE PNEUMATIC DISPATCH.

We illustrate from the American Institute Exhibition, at Armory Hall, Fourteenth street, the Pneumatic Railway, and the Postal Dispatch, both of which have been erected by Mr. Alfred E. Beach, of the *Scientific American.* The first consists of a mammoth tube extending across the building from gal-

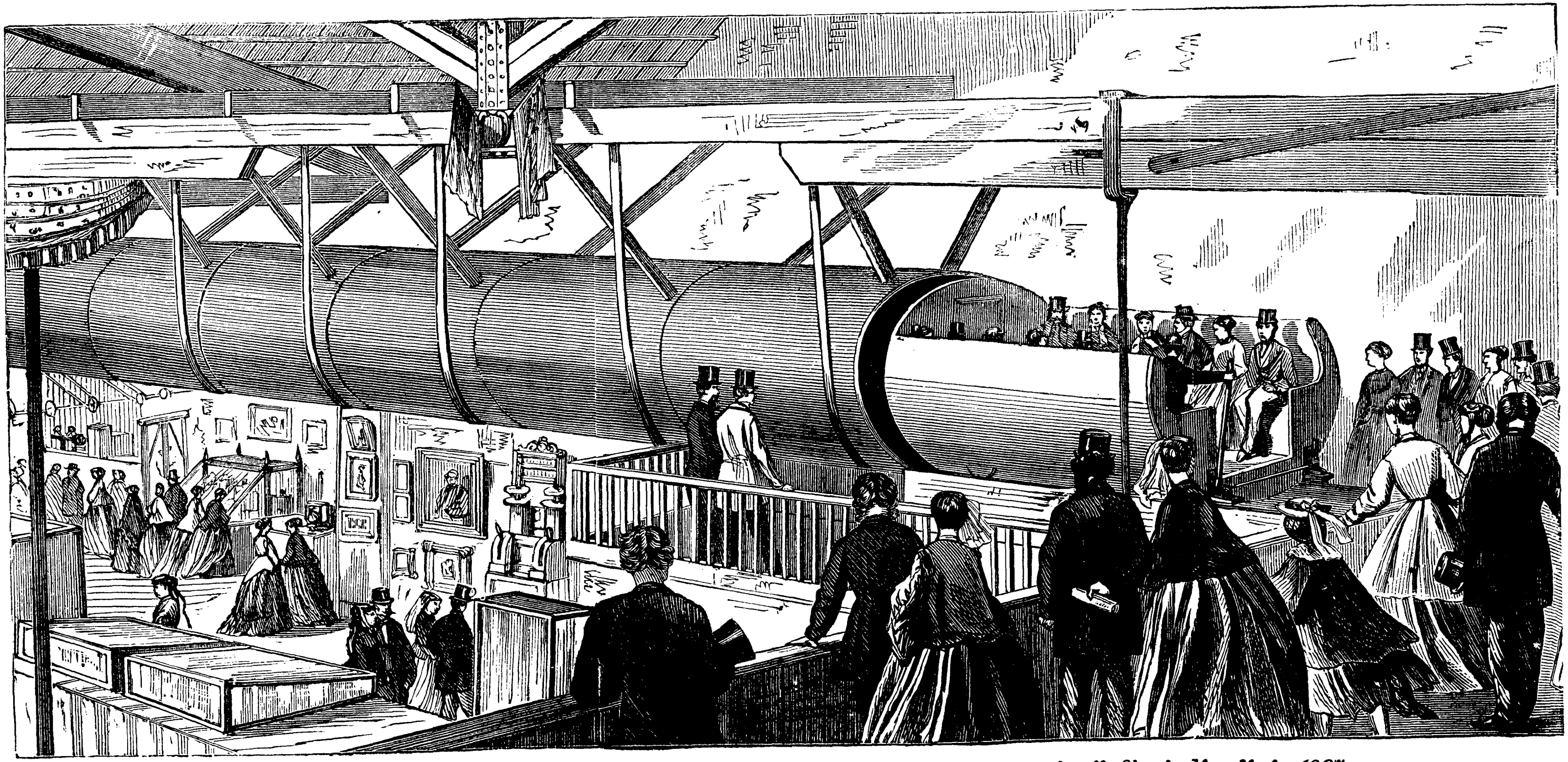


Fig. 7.—The Pneumatic Passenger Railway, as Erected at the American Institute, Fourteenth Street, New-York, 1867.

lery to gallery, supported midway by iron loops pendent from the roof. The tube has inside a track, upon which runs a light, open car, carrying a dozen or more passengers, and making regular trips every two minutes. The tube is lighted by glass windows in the roof. The motive power is an Æolor, or blowing-wheel, having the form of a screw propeller, placed at one end of the tube. Its revolution in one direction sucks the air, and with it the car, into the tube. The reversal of the screw drives the air back against the car and pushes it out. One end of the car is provided with a disk, or head, which fits the tube like a piston and against which the air presses.

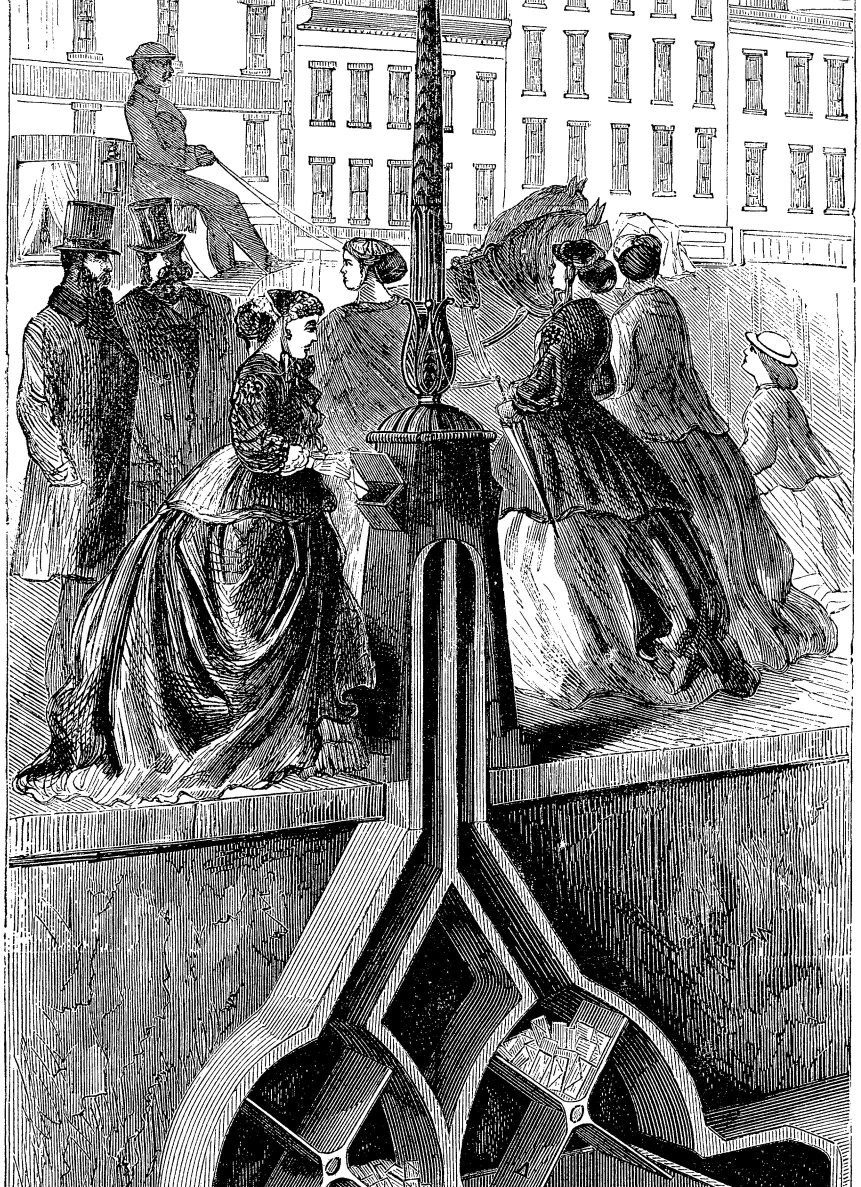
The distinguishing characteristic of the pneumatic system is, that *the car is propelled by the wind.* The car moves with a velocity proportionate to the wind-current produced by the blowing-wheel. Actual experiment proves that there is no difficulty in driving the car at the rate of one hundred miles an hour.

The pneumatic system appears to be admirably adapted to the purposes of rapid city transit, since the ventilation is perfect, and the freedom from all jarring and dust is complete. Mr. Beach is indefatigably laboring to accomplish its introduction here, and it is to be hoped that his efforts will meet with due encouragement and reward. About seventy-five thousand passengers have so far enjoyed the atmospheric ride, and it is expected that more than one hundred thousand will have passed through the tube before the close of the exhibition, about November 1st. As soon as the proper legislative authority can be obtained, it is proposed to lay down tubes under the principal streets and under the adjacent rivers, when, it is stated, passengers will be carried from the City Hall, New-York, to Madison Square in five minutes, Central Park in eight minutes, Harlem and Manhattanville in fourteen minutes, Washington Heights in twenty minutes, Jersey City or Hoboken in five minutes, City Hall, Brooklyn, in three minutes.

THE POSTAL PNEUMATIC DISPATCH.

An examination of the Postal Dispatch (Fig. 8) shows that the letters deposited in the lamp-post boxes fall into the rotary letter-boxes at its base. One of the boxes receives the up-town letters, the other those for down-town. Beneath the boxes, constantly running back and forth in a pneumatic tube, is the Postal Car—a box on wheels—which, as it moves along, touches and turns one of the boxes, so that its contents fall into the car; on the return movement of the car the other box is turned, and its contents collected into the car. Such, in brief, is the operation of the proposed Postal Pneumatic Dispatch. The model actually at work in the Fair makes four collections of the letters every minute, or two hundred and forty collections an hour.

The Postal Pneumatic Dispatch is also the invention of Mr. Alfred E. Beach, and is now for the first time brought to the notice of the public. For the purpose of better illustration, our artist has shown the tube, with its car and letter-boxes, in the relative positions they are intended to occupy in connection with the sidewalk. It is proposed to lay down these postal tubes through all the principal streets of the city, and to have the Postal Cars ply through them, by atmospheric pressure, as often as once in ten minutes. The method of propulsion is the same as that for the passenger car. By means of this ingenious arrangement, all letters or packages deposited in any of the receiving lamp-post boxes below Forty-second street, may be conveyed to the General Post-Office, or to any intermediate station, in six minutes! Welcome!—right welcome!—say we, to the Postal Pneumatic Dispatch!



[From the "Scientific American," Oct. 19, 1867.]

THE PNEUMATIC RAILWAY AND PNEUMATIC POSTAL DISPATCH AT THE AMERICAN INSTITUTE.

THE most novel and attractive feature of the exhibition is by general consent conceded to be the Pneumatic Railway, erected by Mr. A. E. Beach, of the *Scientific American*, and every one visiting the Fair seems to consider himself specially called upon to visit, and, after actual experience, to pronounce his verdict upon this mode of traveling.

It is an interesting sight to stand at the mouth of the great tube and observe the arrival and departure of the car with its loads of passengers. The car fits the tube like a piston, and travels both ways with the utmost regularity and steadiness. Nothing can be more gentle and pleasant than the start and stoppage; no jerking or wrenching of any kind is observable, and although the car is not provided with springs, it rides along very easily. The tube is one hundred and seven feet in length, six feet in diameter, and is composed of fifteen layers of veneers, laid and cemented in alternate spirals, forming a total thickness of an inch and a quarter. This peculiar construction gives great strength and rigidity. The car carries twelve passengers, and its body is rounded on the same curve as the tube. Indeed, the body was made of a section of the tube cut in halves and the ends united, forming a long open cradle without roof, with seats on each side, presenting the appearance of an omnibus sleigh. The wheels project three inches through the shell of the body, turn in boxes arranged under the seats, and run on a small track laid through the tube. One end of the car is provided with a disk or head which fits the tube and forms a traveling piston. There is a door in the disk, also ventilating valves; the lights and water-gauges are also arranged upon the disk. The disk presents a superficial area of twenty-eight feet, against which the atmospheric pressure acts to propel the car.

The Æolor or blowing-wheel is made in the form of a screw propeller. It is ten feet in diameter, made of wood, has eight blades, and revolves at the mouth of the tube opposite to that at which the car enters. When the screw turns in one direction it sucks the air through the tube and the car is drawn in. The car as it passes along moves a lever which gives a signal, and by the time the car arrives near the screw the latter is reversed, which forces a blast of air into the tube and drives the car back. The Æolor is capable of producing a far greater pressure than can be safely used upon the car in so short a length of tube.

There are two of the Æolors at the Exhibition. One of them works the Pneumatic Railway, the other, of smaller size, the Postal Pneumatic Dispatch. Both are driven by one of Root's little trunk-engines, diminutive in size but exceedingly compact, runs beautifully, and gives out abundant power.

The visitors at the Exhibition manifest a lively interest in the Pneumatic Railway, and all seek for the ride. To be carried along by the air pressure is an entirely new sensation. More than twenty-five thousand persons have already been safely carried, much to their enjoyment and satisfaction. Mr. John D. Gilbert is the conductor and accompanies every train. It is probable that a pneumatic railway of considerable length for regular traffic will soon be laid down near New-York, under the auspices of the Pneumatic Dispatch Company of New-Jersey, of which Mr. Beach has lately been elected President. Great credit is due to the Holske Machine Company, who were the builders of the Pneumatic Railway and the Pneumatic Postal Dispatch as presented at the Exhibition. The whole work, tubes, cars, blowing screws and all, were constructed by them in the short space of six weeks. Considering that every thing was of a novel and experimental character, this was making good time. The work was conducted under the immediate personal superintendence of Mr. W. F. Holske, who is one of our most reliable, experienced, and energetic mechanical constructors.

[From the "New-York Tribune," Sept. 27, 1867.]

THE PNEUMATIC PASSENGER RAILWAY AND POSTAL DISPATCH AT THE AMERICAN INSTITUTE.

THE Exhibition of the American Institute has at this time almost reached its culminating point. Nearly all the departments are perfect, and the efforts of the Board of Managers are beginning to show their fruits in the splendid display which is now offered to the public. Upward of 100,000 visitors must have attended the fair up to the present time, and the interest manifested in its many interesting and instructive features are on the increase daily. One of the principal features of the Exhibition—and, indeed, one which has occasioned a vast amount of interest—is the Pneumatic Railway, a model of which has for some time been in the course of erection and completion on the east side of the building; and the importance of this invention, together with the well-founded professions of its projectors and promoters in this country, demand a brief historical and descriptive sketch. The first attempt to use atmospheric pressure, as a locomotive power, was made in 1810, by Herr Medhurst, a Danish engineer, who, it is said, then projected a theory for carrying mail-matter through a pipe, and thus distributing it over a large city, or through a populous province. In 1824 an Englishman, named Vallance, exhibited plans for a Pneumatic Dispatch, and also for a railway carrying passengers on the same principle; but it was not till the year 1832 that plans were so matured that the public were interested in their favor. The pneumatic principle was thoroughly canvassed in England from that time until 1838, when patents were granted to Messrs. Clegg & Samuda, upon models which were considered practicable by some capitalists.

The first railway constructed on this principle was an experiment, two miles in length, from Dalkey to Kingstown, in Ireland, near Dublin. Another, near Croydon, England, over six miles in length, followed; and this was succeeded in 1845 by one in France, between St. Germain and Nautienes, near Paris, a distance of two miles. The main difficulties in these experiments were those attending nearly all embryo schemes of this sort—heavy expenses in working—and they were conducted with varying success. The longest lived of these experiments was that in Ireland, which passed away five or six years ago, being supplanted by a better understood locomotion by steam. The principle in use in this experiment was very different from the one at present in vogue, where the cars pass through the tube. In the former case the tube lay between the rails and below the cars, which were connected with the interior of the tube by iron rods passing from the bottom of the cars through an open slit to the tube below. This slit was closed as fast as the rod cut its way through, by self-closing flanges, which were brought down more firmly as the vacuum was produced inside the tube. The tube was closed at each end, where the engines and air-pumps were situated, by valves of peculiar construction, which allowed the sliding rod to pass in and out freely and smoothly, without letting in the air. (See Fig. 3.) But it was found that the air could not be kept sufficiently confined within the tube by this method, and the experiment was gradually abandoned.

But enough had been demonstrated by the above-mentioned attempts to prove that the principle of pneumatic locomotion was feasible, and the matter obtained the study of both inventors and capitalists. England has been foremost in demonstrating the practicability of the pneumatic principle to the world at large. In 1861 the Pneumatic Dispatch Company was formed in London. The first experiment was made in Battersea Fields, on the south side of the Thames, in the south-west suburbs. An iron tube, a quarter of a mile long and made of iron, was laid along the river bank, and mail-bags, parcels, and even workmen, were carried through at a great rate of speed.

In 1864 a tube of similar construction, 600 yards long, for the carriage of passengers, was built in the grounds of the Crystal Palace at Sydenham, and thousands of passengers were carried through this in a long, roomy car, by a current of air generated by an immense fan, and again drawn back by a vacuum created by the same instrument. (See Fig. 4.) This journey of 600 yards was performed, either way, in fifty seconds, with an atmospheric pressure of only two and a half ounces to the square inch. These successful experiments have been productive of fruitful results. The extensive pneumatic dispatch line which was opened last year from Euston Square to Holborn (two miles) has been successful, and has since been extended to the General Post-Office, another mile eastward.

But the greatest enterprise which has yet been established on this plan is the Waterloo and Whitehall Pneumatic Railway, which proposes to connect the two sections of the metropolis of the world by a tunnel under the Thames, on the pneumatic tubular system. The river will be crossed by four lengths—each 221 feet—of wrought iron tubing, 13 feet in diameter, covered with brickwork. The length of the tubes, including the shore ends, will be five eighths of a mile. The first of these lengths will soon be completed, when it will be floated from the workshops of the contractors (Messrs. Samuda, of the Isle of Dogs) down the Thames to the place of submersion. If this great enterprise should be fairly accomplished, the sub-tubing of the Straits of Dover, forming a railway between England and the Continent, may be considered as a feasible scheme. (See Fig. 5.)

We come to a more intimate interest when we consider the model of the pneumatic railway now on exhibition at the American Institute Fair. Charters for the building of such railways have been granted by the Legislatures of Massachusetts, Connecticut, New-Jersey, and Pennsylvania, and it is understood that two bills will again be presented to the next session of the Legislature of this State, the matter of underground railways having already been placed before that body more than once.

The handsome specimen of a pneumatic railway now erected near the east wall of the American Institute Exhibition is the project of Mr. Alfred E. Beach, of the *Scientific American*.

The tube of the passenger railway at the Exhibition runs from gallery to gallery, and is 107 feet in length. It is six feet long, and is constructed of wood, the shell being composed of fifteen layers of broad hoops, joined together by cement, the whole being only 1½ inches thick, and capable of great resistance. The carriage for passenger conveyance is open at the top and sides, the latter rising sufficiently high to protect the passengers' backs from rubbing against the sides of the tube, the whole having a capacity to seat ten persons on either side. The door is placed in the centre of the O-shaped end, which forms the valve or piston when the door is closed. The four wheels of the car rest on rails laid along the bottom of the tube, and project through the bottom a few inches only. The carriage is just as free from the bottom as from the sides of the tubes. (See Fig. 7.)

The motive power, which is placed at the northern end of the tube, consists of a fan ten feet in diameter, which is, indeed, a screw-propeller, with eight blades, so constructed that the pitch of the blades is not more than twelve inches. This fan, driven by an engine almost immediately underneath, can make 200 revolutions per minute. Turning in one direction, it produces a vacuum by exhausting the air from the tube, and throwing it off through apertures in the chamber, thus drawing, or rather sucking, the car at the other end rapidly toward it. Of course, the motion, when reversed, produces the opposite result, the volume of air then taken from the surrounding atmosphere being poured in a resistless stream *against* the piston or flange of the car, which immediately rushes back to its starting place.

Mr. Alfred Beach also exhibits at the Fair a section of a postal dispatch, through which a truck for the conveyance of mail-matter is drawn or propelled in the same manner explained. The tube itself is square, as are the trucks which pass through it. In connection with the apparatus is an ingenious automatic arrangement, showing how mail-matter, received at different postal depots along the route, may be kept separate and so delivered, and, in like manner, a correct delivery effected at each station of outgoing mails. The lamp-post, containing the letter-box above, rises from the middle of the tube, and every time the subterranean truck passes underneath the contents of the letter-box are made to drop into it, while, in passing in another direction, the contents of another box, designed for a different destination, are collected in the same manner. Thus the car, when passing up-town, collects letters destined for that direction, (having been dropped into the lamp-post receiver above,) and on its down-town trip also collects all the matter gathered in the other box. (See Fig. 8.)

The institutors of several gigantic projects will probably await with interest and anxiety the public verdict in respect to the operations of their models now in progress at the Exhibition of the American Institute. These projected enterprises not only include the establishment of passenger traffic and the transportation of mail-matter throughout the American metropolis —and, indeed, over the whole country—but the more colossal one of sub-tubing the North and East rivers, and thus forming a connection (unexampled for both speed and comfort) between Jersey City, Brooklyn, and New-York.

The actual expense of laying down pneumatic tubes under the streets of the city, it is estimated, would not exceed $500,000 per mile, including the engines and running stock—much less than the putting down of a subterranean steam-car road. The suspension of the model tube at the Exhibition also demonstrates the practicability of an elevated road, and suggests that the tube might be readily laid on posts, or brackets projecting from the houses, or even passing over the house-tops.

Two hundred dollars per foot is the estimated cost of a pneumatic tube under the East River, which, estimating the distance at 3000 feet, would require an outlay of $600,000. The projected suspension bridge over the same stream is to cost $7,000,000, affording a startling contrast in price. It is further estimated that passengers, by a through city tube, could be carried from the City Hall to Madison Square in five minutes, to Central Park in eight minutes, to Harlem and Manhattanville in fourteen minutes, to Washington Heights in twenty minutes, and by sub-river to Jersey City or Hoboken in five minutes, and to the City Hall, Brooklyn, in two minutes, and at a price much less than that at present charged.

The projected Pneumatic Postal Dispatch proposes a wide range of labor. It is proposed to carry a pneumatic tube of about two or three feet in diameter from the Post-Office up Broadway to Forty-second street, with branches at Twenty-seventh street, to the Harlem and New-Haven railroads, and a branch at Thirtieth street to the Hudson River Railroad. A tube is also to girdle the city, passing through South and Washington streets, so as to touch all the ferries and such landings where mails arrive and depart, bringing these points into immediate communication with the General Post-Office. Tubes are also to extend through Chatham street, Bowery, and Third avenue; also along Broad, Pearl, Canal, Grand, Bleecker, and Fourteenth streets, and wherever the public requirements may need them—all the sub-post-offices of course being connected with the General Post-Office. Further, it is proposed to extend the postal tube under the East River, or over the suspension bridge, if constructed, to Brooklyn, and through the principal streets of that city, also under the North River to Jersey City, where it will connect with the Pneumatic Dispatch Company of New-Jersey, to whom, as before stated, a charter has already been granted. By this company it is proposed to extend their line as soon as possible to the nearest important cities, probably Newark and Elizabeth. By means of such a network, no doubt, the mails of the suburbs and suburban cities would be delivered at headquarters with great rapidity. The postal car, it is stated, could be run at the rate of thirty miles per hour, including all delays at intermediate stations. Thus, letters might be sent up-town, as high as Forty-second street and replies received almost with the speed of telegraphic messages.

VARIOUS FACTS IN REGARD TO THE PNEUMATIC PASSENGER RAILWAY—METHOD OF STOPPING AND STARTING THE TRAINS AT THE PASSENGER STATIONS—PLANS FOR AN ELEVATED PNEUMATIC RAILWAY—HEATING AND VENTILATION.

STOPPING AT WAY STATIONS.

In the construction of a pneumatic passenger railway it is a matter of prime importance, having in view the utmost economy of construction, to make the tube as small as may be consistent with the safe, comfortable, and rapid transport of passengers. The inquiry naturally arises, If the car closely fits the tube, how are the trains to be stopped at the way stations?

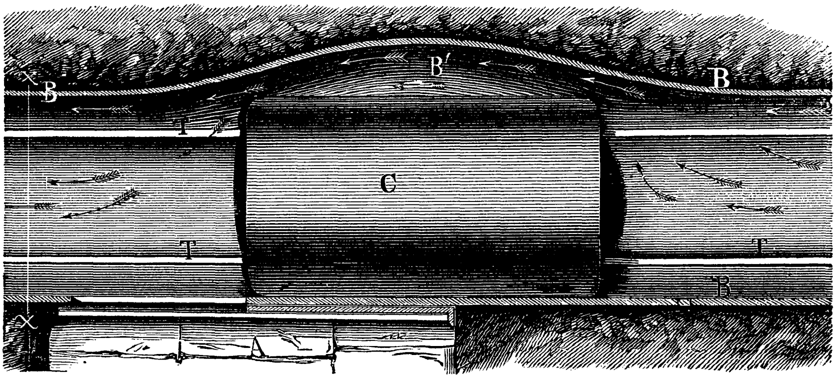


FIG. 9.—METHOD OF STOPPING PNEUMATIC CARS AT WAY STATIONS.

The method of stoppage, which is very simple, will be readily understood by a glance at Figure 9. A represents the platform of the station, BB the pneumatic tube, B′ an enlargement of the tube, C the pneumatic passenger-car, standing at the platform, TT the track. The course of the air-current by which the car is driven is indicated by the arrows. In consequence of the enlargement of the tube at and near the station, the onward passage of the air is permitted around one side of the car, while the latter is brought to a halt at the station by means of brakes. To start the car, it is only necessary to release the brakes when the pressure of the air against the rear of the car will carry it slowly forward into the neck of the tube at XX, where the car will then receive the full force of the air-blast, and speed on its way to the next station with full velocity.

HEATING AND VENTILATION OF PNEUMATIC CARS.

No stoves or fires will be carried upon pneumatic passenger-cars, but they will be heated by means of hot water foot-cases, similar to those used upon the French railways. This is one of the safest and most comfortable methods of car-heating that has yet been introduced.

As respects the ventilation of passenger-cars, the pneumatic system is the perfection of traveling. The driving-power is a column of moving fresh air, which is pressing against the sides and rear of the car, seeking everywhere to find entrance to the interior of the car. An abundance of ventilators are provided, by which pure fresh air is at all times admitted, and perfect ventilation secured. No dust or cinders are encountered by the passenger, and he reaches his journey's end without injury to his apparel from these causes, and without having the complexion smutted with smoke.

In summer the pneumatic railway will afford a cool and delightful refuge from burning heats, and the passenger will enjoy the luxury of reclining at ease, to sleep or read, and, also, of being transported gently, at a high velocity.

ELEVATED PNEUMATIC RAILWAY.

In Figure 10 we have an illustration of the pneumatic railway upon the elevated plan, designed by Mr. A. E. Beach.

The engraving shows, at the left, the arrangement of a light wooden pneumatic tube, upon ornamental columns.

At the right the tube is represented as resting upon brackets attached to the buildings. Another plan is to run the tubes over the tops of the houses; and another is to extend them through the existing vaults under the sidewalks of the principal streets.

These plans possess the merit of cheapness in execution. They could be put in operation for a less expenditure than the street tunnels, would afford a most rapid and reliable means of transit for passengers, and would present a less cumbersome appearance than the elevated railway bridge now erected on the west side of the city.

[From the "Scientific American," January 5, 1867.]

THE PNEUMATIC DISPATCH.

The growth of the business and population of New-York City is wonderful. Twenty years ago we numbered less than four hundred thousand inhabitants, while to-day we have nearly one million, and if the same ratio of increase continues for twenty years longer, we shall then count three million. Already our streets, spacious, compared with many large cities, are over-crowded; public conveyances impede each other, and can only travel at slow pace. The carrying traffic has become so enormous, the

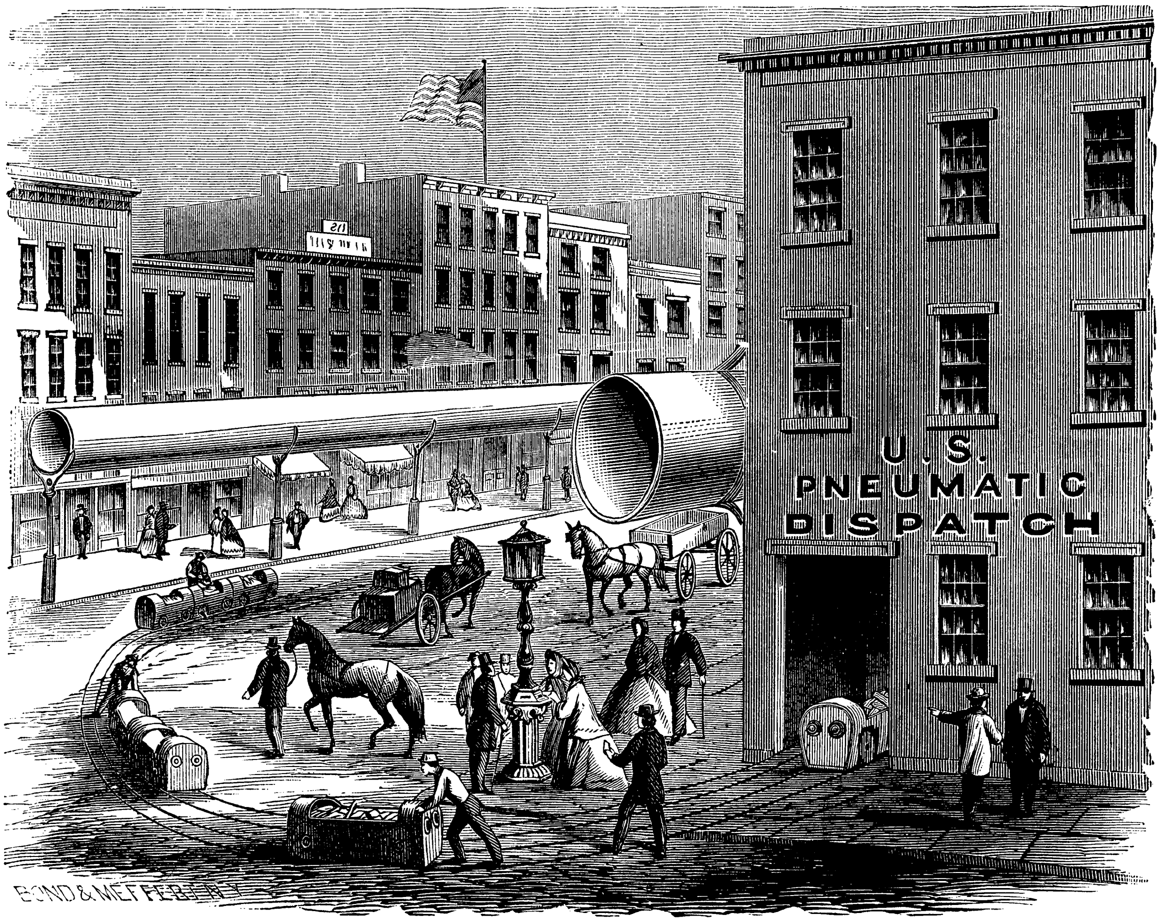


Fig. 10.—The Pneumatic Elevated Railway. (Designed by A. E. Beach.)

number of men, horses, and vehicles so great, that they frequently blockade the streets, move with difficulty, and of necessity their charges are high. It costs more to carry a barrel of flour one mile within the streets than to transport it hither from the mills, distant two hundred miles.

The city postal service, excellent in some respects, fails to afford a tithe of the assistance it is capable of rendering in the transactions of ordinary business. No person expects promptness in the delivery of city parcels and letters; as for out-of-town mails, letters fail to go unless they reach the General Post-Office down-town from one to two hours prior to the departure of the car or boat.

The need of some method of relieving the streets and affording to the public more abundant, quicker, and cheaper means of local communication was never more pressingly felt than at present.

We are glad to observe that a movement is being made which promises something practical in respect to the faster conveyance of passengers. We understand that the Senate Committee of the Legislature has decided to report in favor of a tunnel passenger railroad, to extend from the southern extremity of the island, under Broadway, with branches under Third and Eighth avenues, to Harlem River, a distance of eleven miles.

Of almost equal importance to the material prosperity and business convenience of the city, is the introduction of an underground method for the safe, prompt, and economical conveyance of all kinds of freight, goods, parcels, and the mails.

To this service the Pneumatic Dispatch system is admirably adapted, and to some of its practical uses we propose now to direct the attention of our readers. The system of communication now generally known as the Pneumatic Dispatch consists in the employment of a closed tube, through which air is driven or exhausted by means of steam-power and blowers of large dimensions. Cars or trucks, closely corresponding in form to the shape of the tube, are employed therein to carry freight, and these are sucked or blown along, from station to station, literally with the speed of the wind. The Pneumatic Dispatch is now employed in London with complete success. By it freight, mail-bags, etc., are transported with a velocity of thirty miles an hour, up hill and down, around the sharpest curves, with great economy. A velocity of fifty or one hundred miles, or even more, per hour, may be obtained, if desired, by simply burning more coal and driving the blowing machinery faster.

The Pneumatic Dispatch system is also well adapted to the propulsion of passenger-cars, and for city use it is probably more economical and safer than any other known means. The superior economy of stationary engines for steady work is well known. Between pneumatic trains there can be no collisions; the same current drives them all; if one train stops on the track, no other can approach it; no engineers and firemen are required on the cars; no gas or smoke is evolved; the tunnel and cars are constantly supplied with moving fresh air; the cars run with peculiar steadiness, without any jerking at the start or stop. With an atmospheric pressure of only two and a half ounces to the square inch on the rear end of the car, a velocity of twenty-five miles an hour is obtained. The use of the pneumatic passenger cars in London established these facts long ago.

We have selected for illustration, in connection with this subject, the application of the Pneumatic Dispatch to the city postal service, from designs by Mr. A. E. Beach, of the *Scientific American*.

The engraving herewith presented, Fig. 12, is an interior view of a supposed Pneumatic Dispatch station. Passing through the apartment is seen the main pneumatic tube, *g*, having side switch-tubes, *h*, through which the pneumatic cars enter and leave the station. Each car, on emerging from

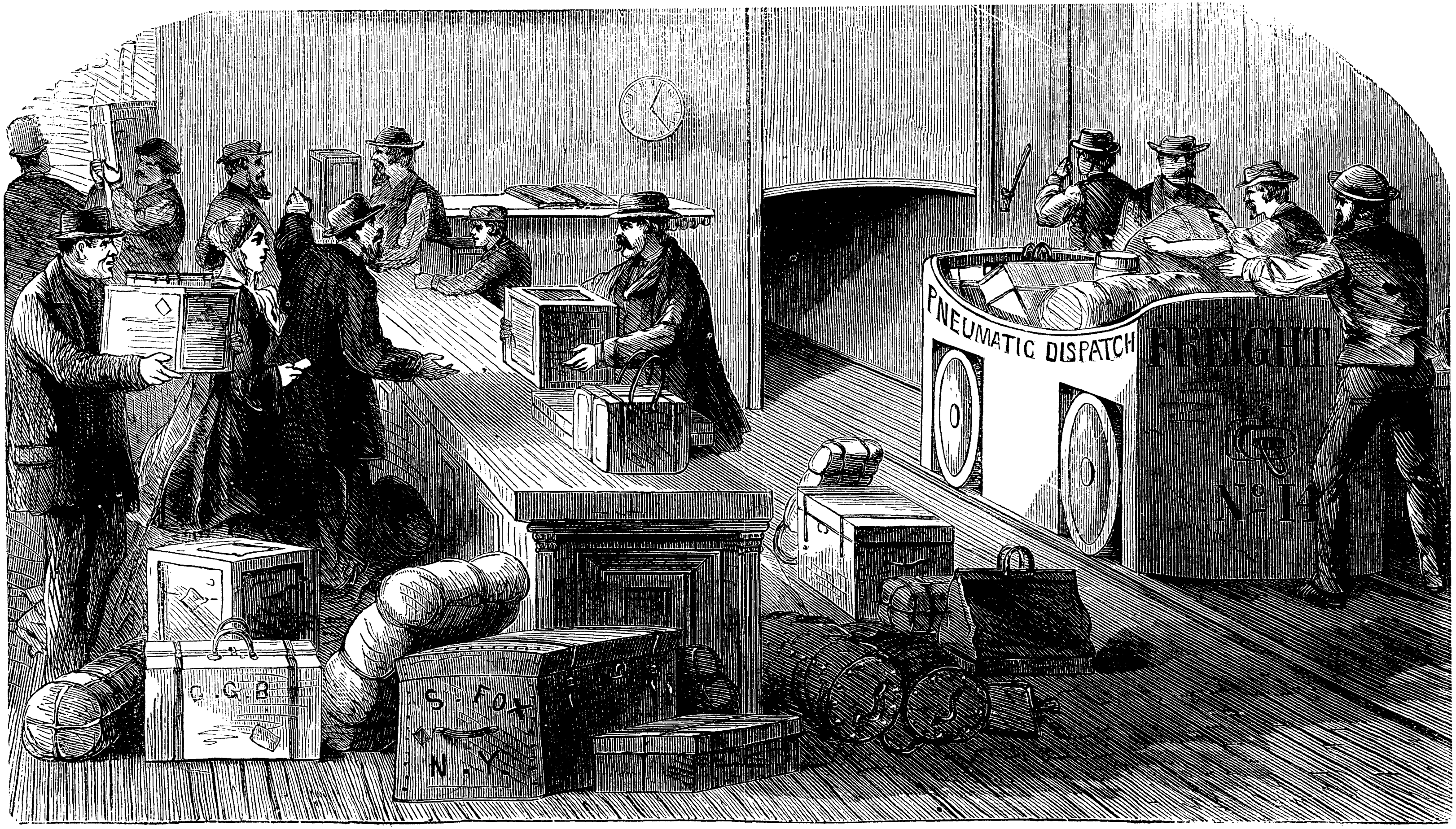


Fig. 11.—The Pneumatic Dispatch—Proposed City Receiving and Delivering Station.

the switch-tube, is carried by its momentum across the floor into a short tube, *h'*, which serves as an air cushion and gently arrests the car.

The automatic letter-distributing mechanism is seen in front. The packages and letters destined for different city stations are placed by the attendant in the rotary letter and parcel boxes, A B C, which indicate the stations to which the packages are to be conveyed and delivered. The pneumatic car is divided into compartments corresponding respectively to the boxes, A B C, and when the car passes through the tube under these boxes, a pin, *b*, upon the car, strikes a projection, *a*, upon the blade of each rotary box, and causes it to turn upon its axis far enough to compel the contents of the box to fall into the car beneath. Each car is similarly operated by a separate pin, *b*, and thus the contents of the several boxes at the various stations on the route are successively transferred into their corresponding car compartments, without any stoppage of the car. When it is desired to send the cars through the tube without operating the boxes at the stations, it is only necessary to remove the pins, *b*.

The delivery of the contents of the car at the appointed stations is accomplished by opening the car bottom, each compartment bottom, *f*, being hinged for that purpose. On reaching station A, for example, the rod, *e*, which rests upon the car bottom and projects above the top of the car, will come in contact with an inclined lug, fastened in the roof of the tube, *g*, which lug will depress the rod, *e*, and cause it to open the bottom of compartment A, and the contents thereof will drop out, through an opening in the bottom of the tube, upon a table, or other receiver, within the station. A similar transfer takes place at each station from each car compartment corresponding to that station, without stoppage of the car. By this simple means, the collection, transportation, and delivery of letters and parcels may be automatically effected throughout the entire city, with extraordinary rapidity, safety, and economy.

The delivery of the contents of a car upon the table of a station is illustrated in the accompanying engraving, Fig. 13, where the main pneumatic tube passes through the basement. In the receiving office above is a series of slides or tubes, which communicate respectively with a series of rotary letter-boxes, A B C D E F, mounted upon the main tube below. These letter-boxes indicate so many stations to which letters are to be sent, and they are distributed by the attendant into the slides, A B C D E F, down which they fall into the letter-boxes, where they remain until a car comes along, which takes them out and carries them to their several destinations, in the manner before described.

Fig. 14 represents a lamp-post letter-box, and under its base are two rotary boxes, one for up-town letters, the other for down-town letters. The pneumatic cars are intended to pass under these lamp-post letter-boxes, to collect and carry the contents, as already described.

By the use of the Pneumatic Dispatch letters and parcels may be collected, conveyed, and delivered from and between all stations and lamp-posts below Forty-second street and the Post-Office, Nassau and Liberty streets, in six minutes—distance three miles. Letters deposited in any pneumatic post or station, in any part of the city, fifteen minutes before the departure of any mail, will be in time for such mail. Messages, letters, and parcels could be sent to any address, up or down town, and the answer returned, all within an hour's time, or even less.

Among the first results of the introduction of the Pneumatic Dispatch, in connection with the postal service, would be an enormous increase in the number of letters sent. It would soon become the great popular means of communication, a sort of Hermes, or winged messenger, employed by the gods, as we read in ancient mythology, but in these modern times transferred to the service of the sovereign people.

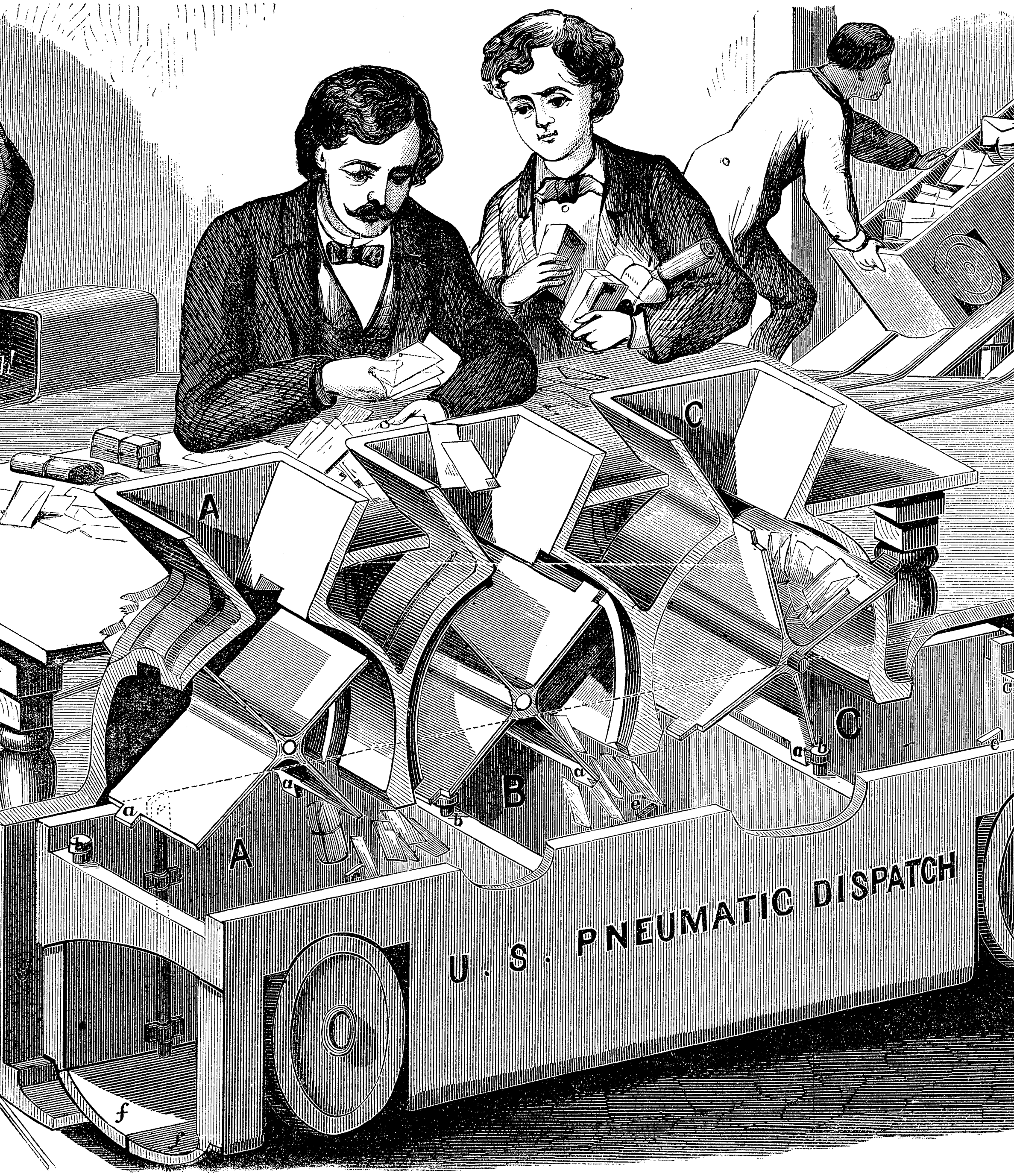


Fig. 12.—The Pneumatic Dispatch—Applied to Postal Service. From Designs by A. E. Beach.

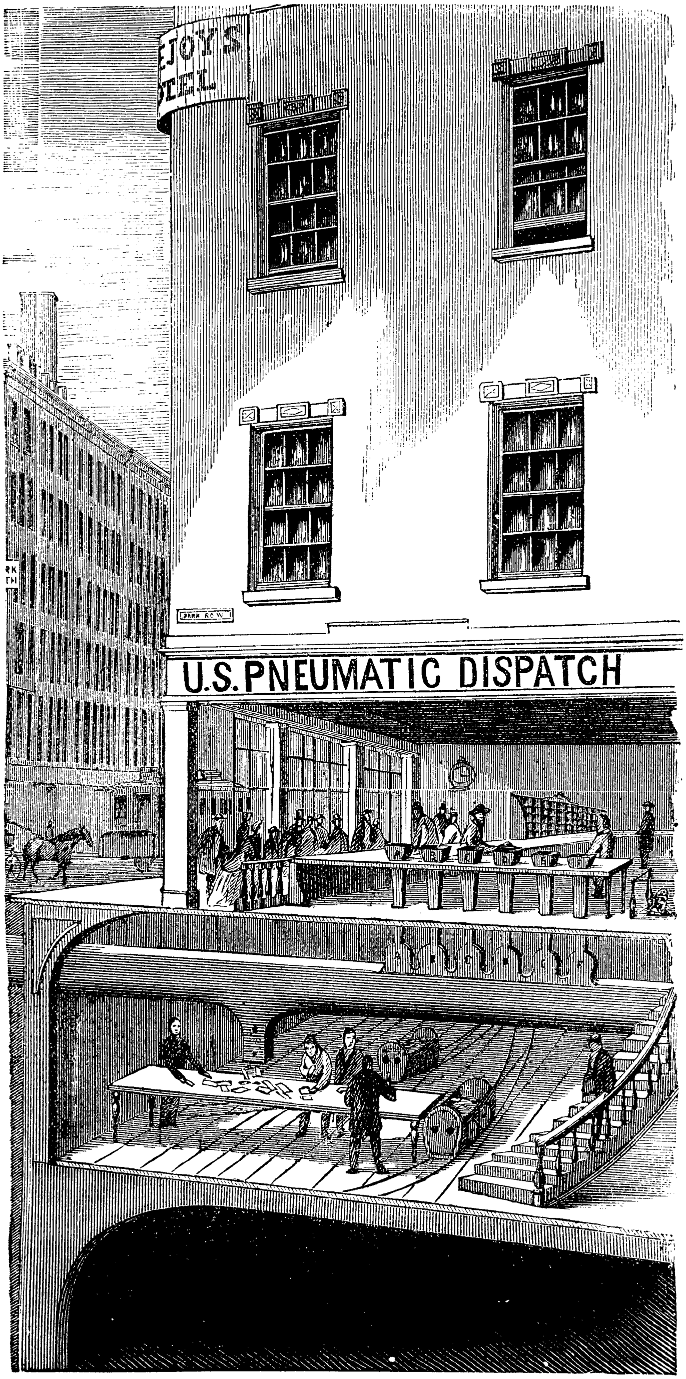


Fig. 13.—The Pneumatic Dispatch—Receiving and Delivering Station.
From Designs by A. E. Beach.

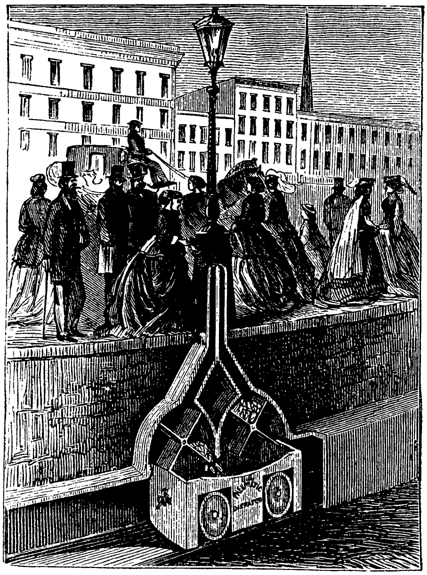


FIG. 14.—THE PNEUMATIC DISPATCH—TAKING LETTERS FROM THE LAMP-POST.

[From Designs by A. E. BEACH.]

Independent of the postal service, which of itself would bring in an immense revenue, and soon repay the cost of construction, the additional existing business which the Pneumatic Dispatch would command at once in the city of New-York, by its unapproachable cheapness and facility, is something remarkable. We have been at some pains to investigate the daily movement of packages and parcels through our streets, and the result, we think, will surprise those who are best acquainted with the business.

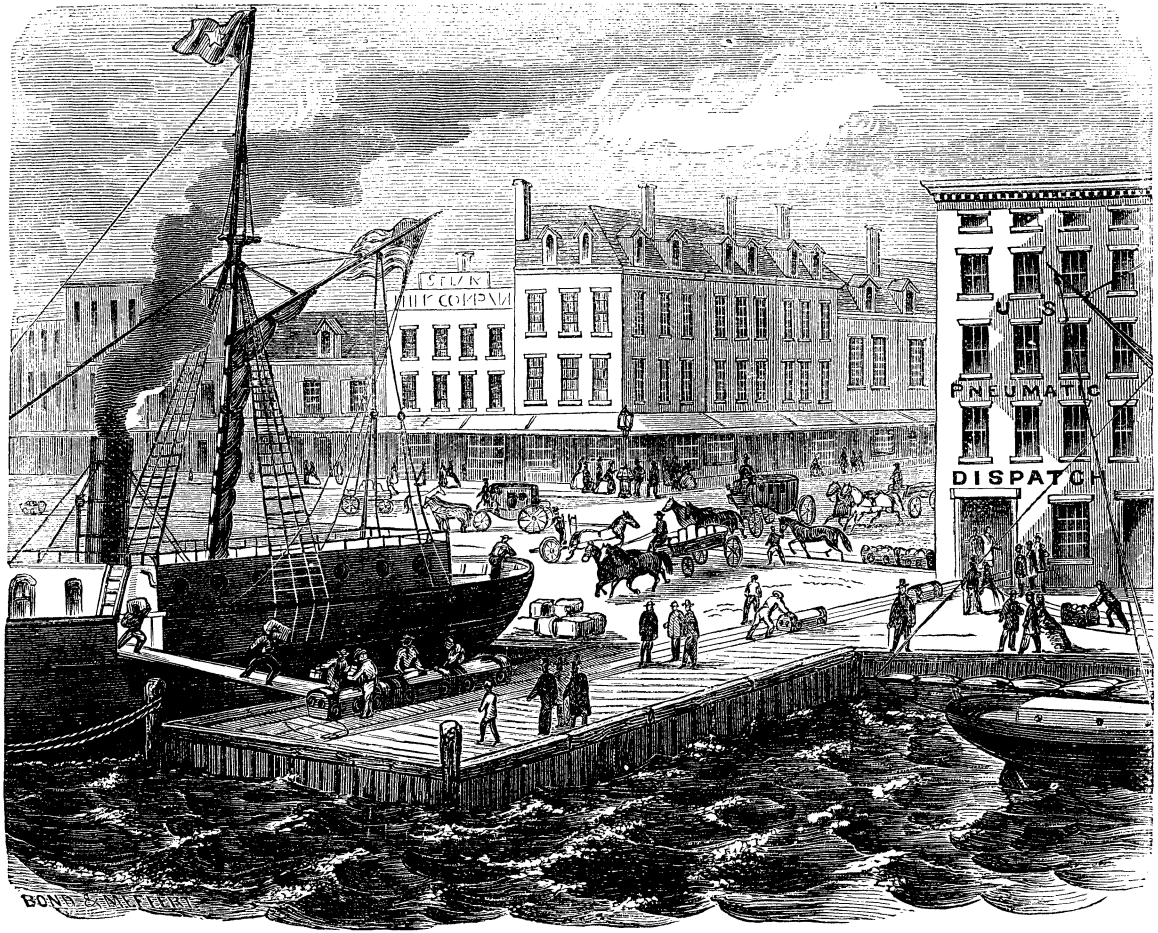
There are two or three leading express companies which collect and distribute three or four thousand packages each per day; each employing from fifty to a hundred horses, and as many men. But these mammoth establishments take up but a drop of the flood, comparatively. We have at least a dozen important express lines to the interior, constantly employing in our streets an aggregate of nearly a thousand men and horses, in the collection and distribution of not less than fifteen thousand parcels of all sizes per day. But the city express system is entirely additional to this, and twice as large. All the out-of-town express matter is collected and distributed here by the companies without charge to their customers, and consequently pays no license fee to the city. But the number of licensed express wagons doing business for hire within the city is over eleven hundred; and their daily parcels must exceed thirty thousand, if each wagon be allowed only thirty calls per day, which would barely support man and horse. Again, this does not include the suburban express wagons, which are licensed in their respective localities, although their business is wholly to and from this city, and of which some two hundred and forty come over every day from the city of Brooklyn alone. Jersey City, Hoboken, Hudson City, Weehawken, Newark, Staten Island, Flushing, Astoria, Jamaica, Flatbush, and many other places, send in their full quota of daily express wagons; so that five hundred suburban expresses, with their fifteen thousand daily parcels, must be considered a very moderate estimate.

But all this is a sort of excrescence, the growth of a few recent years, upon the main body of our system of street transportation. The public cartmen number upward of seven thousand, with two hundred and seventy-five public porters. Of the private carts and wagons belonging to our wholesale merchants, manufacturers, and large retail houses, we can only make inadequate conjecture, so as to be within bounds. Of our eight thousand wholesale merchants, at least one thousand have their own carts. The manufacturers, who, for the most part, can not dispense with private wagons, can not possibly have less than two thousand of these in motion. Here are ten thousand vehicles in the wholesale way. Then we have seventeen thousand retailers and eleven thousand in mechanical trades. Of these, some three thousand grocers, and two thousand butchers and bakers, must have, nearly all of them, wagons for the collection of their numerous daily supplies of goods or materials, as well as for distribution to their customers. Allow them four thousand wagons, and let the other twelve thousand retailers have one thousand more. Total of public and private business vehicles fifteen thousand, beside expresses. Give them a low average of thirty parcels per day—many of them carry hundreds—and we have a total movement of four hundred and fifty thousand parcels. To these add fifteen thousand out-of-town express parcels, fifteen thousand suburban, and thirty thousand city, and we have a total of five hundred and ten thousand per day.

Half a million of parcels and packages already passing through our streets daily by horse-power—to which we might fairly add a hundred thousand more by hand—furnish the existing basis of business strictly legitimate for the Pneumatic Dispatch, and capable of being transacted by that agency at a decisive saving in cost. The latter fact will be apparent on a simple calculation. The cost of a horse in this city, well cared for, is found by accurate account to be about sixty-five cents per day. The wages of employees are about three dollars, and the earnings of cartmen five or six dollars, at the lowest. Allow the men an average of four dollars, and let the wear of wagon and harness, with the expenses and wear of the horse, make up one dollar a day. Too little, every one will say; but here are over seventeen thousand horses, as many wagons, and as many men, maintained at a minimum cost of eighty-five thousand dollars per day, which is an average cost of seventeen cents for every one of the half million parcels they are supposed to carry. Of course the *price* paid, directly or indirectly, must be higher. Any one generally acquainted with such prices in the city will admit that twenty-five cents would be a medium estimate for the average.

Reduce this price to an average of ten cents, which would be a lucrative rate for pneumatic transportation, and you have instantly the proper condition for doubling the business, which the quickness, certainty, and facility of the new method would soon double again.

Again, as to capital: here are seventeen thousand horses, worth, on an average, three hundred dollars each, and as many wagons and carts, worth an average of two hundred dollars more; making a total capital of eight million five hundred thousand dollars invested in this business in the form of horses and vehicles alone—enough to extend the pneumatic system through every thoroughfare of the city twice or three times over.


STEAM
HIP COMPANY
U. S.
PNEUMATIC
DISPATCH
BOND & MEEBERT

CHAPTER VI.

PROPOSED CONNECTION OF NEW-YORK CITY, BROOKLYN, JERSEY CITY, AND STATEN ISLAND, BY MEANS OF THE PNEUMATIC RAILWAY AND SUB-AQUEOUS TUNNELS—DESCRIPTION OF VARIOUS SUB-AQUEOUS TUNNELS NOW CONSTRUCTED AND PROPOSED—BRIDGE VS. TUNNEL—DE SENDRINIER'S TUNNEL—HOLCOMB'S PLAN FOR A RIVER-TUNNEL—DIXON'S METHOD OF CONSTRUCTING RAILWAY-TUNNELS—THE PNEUMATIC DISPATCH COMPANY OF CONNECTICUT.

[From the "Scientific American," Jan. 11, 1868.]

COMMUNICATION BETWEEN NEW-YORK, BROOKLYN, AND JERSEY CITY.

WE publish, in another column, accounts, furnished by a correspondent, concerning the construction of sub-aqueous tunnels, with a view of showing the feasibility of establishing this means of communication between New-York, Brooklyn, and Jersey City. From these accounts, it would seem to be no very difficult or expensive work to connect these great cities by a single tunnel, which, although of small dimensions, would have an immense carrying capacity for passengers. Indeed, through the proposed eight-foot tunnel it is stated that twice as many passengers can be conveyed as are now carried on all the combined Brooklyn ferries, and there would never be any interruption of travel by snow, ice, fog, or collision. The proposed tunnel would be about the same in cross section as the Croton aqueduct, which is 53½ feet. This great tube is over forty miles long, and was built in five years' time, at an expense, including right of way, land, dams, bridges, reservoirs, and other large extraneous expenses, of about sixty dollars per running foot. The actual expense of constructing the tunnel proper did not probably exceed twenty dollars per running foot. We should be glad to receive information upon this point.

The area of the proposed sub-aqueous railroad tunnel, as described by our correspondent, is sufficient to take in cars of about the same interior accommodations as ordinary railway cars.

It is well known that the beds of the North and East rivers are of such a nature as to present no serious obstacle to the laying down of tunnels. Undoubtedly, the quickest and best way would be to dredge a ditch deep enough to contain the eight-foot tube, and sink the same below the bed of the river; the construction and laying being executed on the plans of Trevethick and other distinguished engineers.

Between Brooklyn and New-York the sub-aqueous portion of the tunnel needs to be only 2000 feet in length; and an enterprising corporation might readily put it down and have it in operation in six months' time.

A tunnel could be laid down and put in operation four years in advance of this bridge, the construction of both being commenced simultaneously. During these four years the stockholders of the tunnel would probably receive back their capital two or three times over, in the shape of dividends.

The bridge will cost fourteen times more than the tunnel. Consequently, in order to pay the same interest on its cost as the tunnel, the bridge must yield to its stockholders an income fourteen times greater than the tunnel.

SUB-AQUEOUS AND OTHER TUNNELS.

EDITOR SCIENTIFIC AMERICAN:

The return of the inclement season, when boats and vehicles are liable to be impeded by snow and ice, will probably lend interest to the consideration of additional methods of communication, especially between large cities and their immediate suburbs. The subjoined history of various tunnels and projects has been compiled with a view to call the public attention anew to the subject.

THE THAMES ARCHWAY COMPANY.

Among the earliest of the projects for sub-aqueous tunnels were those introduced under the auspices of the Thames Archway Company, of London, in the beginning of the present century. This corporation, having obtained authority from Parliament, raised subscriptions to the amount of £200,000, and prepared, in 1809, to construct a tunnel under the Thames river for carriages and foot-passengers. The charter prohibited them from obstructing navigation, and the company started with the idea of operating wholly below the bed of the river. The first business was to bore a preliminary drift through the route of the proposed tunnel, in order to ascertain the exact nature of the soil and the difficulties, if any, that the builders would probably encounter. Richard Trevethick was the engineer of this drift. A shaft of nine-inch brickwork was first sunk on the south bank of the Thames, to a depth of 76 feet below high-water mark, and the drift was then extended horizontally toward the opposite bank of the river. The drift was a temporary tunnel, 5 feet high, 3 feet wide at the bottom, and 2 feet 6 inches at the top. It was lined with a frame of 3-inch planks.

The drift was successfully prosecuted for a distance of 922 feet, which was further than the actual width of the river, the real width being 850 feet at high water and 649 feet at low water. The drift was purposely run out in various directions, diverging from the true line, in order to test the soil. At the extreme end of the drift, before it had quite reached the opposite bank of the river, the engineer encountered a quicksand, and finally gave it as his opinion that the construction of the proposed excavated tunnel on that line was impracticable. He, however, suggested other plans for laying a tunnel which he considered entirely practicable. Other engineers were, however, of opinion that the original plan was practicable, notwithstanding the quicksand. The directors concluded that, in so novel and important an undertaking, it was desirable, before adopting any plan, to endeavor to avail themselves of the best which the engineering talent of the country could suggest. They accordingly caused advertisements to be published in the newspapers, offering a premium of £200 for the best plan of construction, and a further sum of £300 when such plan had been successfully completed.

In response to this advertisement no less than fifty-four plans were submitted, and were examined by two able scientific men, entirely disinterested—Dr. Hutton and Mr. William Jessop. Many of the plans had great merit, but all were, for various reasons, rejected, except six; and of these the examiners finally selected, as best of all, the joint project of Mr. Charles Wyatt and Mr. Hawkins.

We propose now to give a brief outline showing the nature of each of these six projects, which, at that time, (1809,) attracted great attention. The plans were presented anonymously to the company, and we are therefore unable to present the names of the projectors, except in some instances.

PLAN FOR A BRICK TUNNEL.

The tunnel to be of brick, a complete circle, 13 feet diameter, three bricks thick, having a carriage-way, 7 feet 9 inches, between the curbs, a foot-way on one side, lamps the other. As this tunnel would be buoyant, the projector proposed to cover and ram it six feet below the bed of the river, with clay. In laying down this tunnel, the projector proposed to form coffer-dams, of fifty feet length at a time, in the direction of the tunnel, the walls of the dam being formed by driving down piles; the spaces between the piles to be filled with prisms of wood, and the whole carefully calked; the bed of the river to be then excavated and a section of the tunnel built. While this was going on, another section of dam to be put down. The piles to be sawed off even with the river-bed on completion of each section.

PLAN FOR A CAST IRON TUNNEL.

This plan was by R. Trevethick, the distinguished engineer to whom is due the credit of the high-pressure steam-engine. This tunnel was to be 12 feet in diameter, composed of cast iron slabs, each 6 feet long, joints to be calked. The method of laying down was to excavate the bed of the river from within a set of piles driven down within a movable coffer-dam. The movable dam or caisson to be 50 feet long, 18 feet wide, 40 feet deep, made of 12-inch square logs, fastened with trunnions and calked. The caisson to be provided with two water-tight compartments, to float the whole machine. A sufficient weight of ballast to be used to sink the caisson when water is admitted to the compartments. The caisson being floated to the desired position, plugs in the compartments are withdrawn, water is admitted, and the caisson sinks, and its bottom rests upon the bed of the river. Guiding frames are then arranged within the caisson, piles driven, a ditch or channel for the tunnel excavated, the tunnel-plates put together, and the excavated earth rammed down upon the tunnel even with the bed of the river, as fast as completed. When as much of the tunnel is complete as the length of the caisson permits, the latter is floated and moved one length ahead, the mouth of the tunnel being first stopped with clay and piles to prevent ingress of water. The water within the caisson is to be drawn off by boring an opening down into the existing drift, described in the first part of our subject. This plan for building a tunnel was highly commended for its ease of execution, simplicity, and cheapness. Brick, if preferred, could be used instead of iron.

PLAN FOR A TEMPORARY CAST IRON, AND PERMANENT BRICK, TUNNEL.

The projector of this plan proposed—first, to lay down a tunnel of cast iron, to be laid in a ditch dredged in the bed of the river. After the iron tunnel was completed, he proposed to construct a brick tunnel by boring, the line to be deep enough to insure solid ground, below quicksands, etc. The iron tunnel he proposed to construct of separate cast plates, provided with flanges, and secured together with bolts. The laying of the tube was to be accomplished by means of capacious iron diving-bells, fitted with the means for convenient access of men and materials, air-pipes, etc., operated by steam-engines. It will be seen that the American patents granted for cast iron tunnels screwed together were anticipated in England more than fifty years ago.

GROOVED STONE TUNNEL.

This plan provided for the laying of a stone tunnel thirty feet in diameter, the edges of the stones to be tongued and grooved, and joined with water-proof cement. The stones to be carefully prepared before being brought to the river. Movable coffer-dams were to be employed, within which a ditch was to be excavated and the tunnel constructed. The bottom edges of the dams were to be provided with a flexible curtain of tarpaulin, to prevent bottom leakage. The tunnel was to be two feet below the bed of the river, covered with clay, well rammed. This plan is somewhat similar to Trevethick's, before described.

A TUNNEL OF BRICK OR OTHER MATERIAL.

This plan provides for a tunnel to be laid like the foregoing in a ditch to be opened by means of a coffer-dam. The tube to be covered with earth after construction, and rammed, so that the bed of the river directly over the tunnel will not be elevated. The chief peculiarity was in the construction of the dam, which was to be ninety feet in diameter, made up of stave logs a foot square, the bottom ends of the logs to rest on the bed of the river. Stability was to be given to the staves by means of internal hoops. After one section of the tunnel had been completed, the dam was to be taken apart, moved along, and erected for the building of a new section.

PLAN FOR A WOODEN TUNNEL.

Apparently the cheapest of any of the plans, and perhaps the most easily executed, was another of Trevethick's designs for a wooden tunnel, sixteen feet in diameter. The drift previously constructed by him was to be used for drainage of the wooden tunnel.

" The cut across the Thames is to be made beneath the water by a steam ballast-raising engine twenty-four feet deep below the bottom of the river, and wide enough to receive the wooden tunnel, and with its sides sloped in an angle of about 45°. This cut is to be nearly horizontal at the middle of the river, but declining about six inches toward the south, for delivering the water from the road down into the drift; the remaining parts at each side are to be inclined one foot in fourteen, which is about the degree of inclination of the bottom of Holborn Hill.

"This slope will ascend to the surface at the south side about 100 feet south of the shaft, and at the north side about 150 feet north of Queen street, in the field adjoining to the Commercial Road; making the total length of the tunnel about 2010 feet.

" All the earth that is above low water mark may be removed with spades.

" The wooden tunnel, for which this cut is to be prepared, is to be made of elm, in lengths of from 180 to 200 feet of six-inch plank, placed two in thickness, or in two layers, laid so that the joints shall be covered by the planks in the other layer, fastened together with trennels, hooped outside with iron, calked, pitched, and made water-tight like a ship. The hooping to be put on in a spiral form, with the spirals two feet asunder.

" The ends of each length of the tunnel are to be made to fit into each other, or to be put together with cast iron ferrules, of six feet long, similar to the joints of a flute.

" Each of these wooden cylinders will weigh about 200 tons, and may be moved in water nearly as easily as a loaded barge. As many of these cylinders are to be prepared as will extend from side to side of the river, above low water mark, when joined end to end, which will be about 1340 feet. From each end of the wooden tunnel to the entrances, the passage is to be left at intervals open to the surface, to admit light, and is to have both its sides and bottom constructed of brickwork eighteen inches thick. This part will extend about 670 feet, (at each side,) and will complete the tunnel from the surface at one side of the river to that at the other. Staircases for descending into the tunnel are to be formed at each side; the interval of the tunnel between these, which will be about 876 feet, must be lighted by lamps always; the remaining 464 feet (at each side) will receive daylight through apertures made like wells from the surface, at intervals of about thirty feet from each other.

"After the cut is excavated, piles are to be driven at its eastern side, about sixty or seventy feet asunder, to guide the wooden tunnel into its place. Then the wooden cylinders, (which are intended to be made near the Surrey Docks,) being ready, are to be rolled into the docks from the banks, and to be towed to the cut, a little before low water, when there is little or no tide, being previously loaded with rubbish sufficient to sink them, but kept buoyant by empty casks attached to them. Here they are to be placed across the river, resting against the piles above mentioned, their ends to be joined into each other and to be drawn tight together by a rope and chain, put through them from end to end.

"At extreme low water the lashings or cords are to be slipped from the casks, and the cylinders are to be let to sink altogether to the bottom of the cut, which is to be then filled up with strong clay, well rammed down even with the bottom of the river. A hole is then to be bored into the bottom of the tunnel from the roof of the drift, (which is to be previously dug beneath the cut,) to let the water down from the tunnel to the well of the steam engines.

"When the tunnel is drained, it will have a great tendency to float, but, having an average of eight feet of clay above its top, with the weight of the road inside, its buoyancy will be overbalanced. If, after a number of years, the wooden cylinders decay, they may be easily replaced by putting cast iron cylinders, one inch and a quarter thick, inside; and if any difficulty is found in letting down the whole of the cylinders at one time, they may be put down separately, and afterward be joined together beneath the water.

ESTIMATE OF COST FOR 1340 FEET, AND THE LAYING THEREOF UNDER THE RIVER.

Cutting from low water mark to the first light well at both sides, 690 feet long, 80 feet wide at top, and 36 deep, about 45,000 tons, at 2s.	£4,500
Cutting from said light wells to each entrance, 640 feet long, about 30 feet wide, and 12 deep, estimated at 6500 tons, at 1s. 6d	487
Wooden tunnel, 1340 feet long, 16 feet diameter from out to out, 1 foot thick, estimated 94,470 feet, of rough elm, or 2362 loads, at £7 per load	16,534
Making, calking, and paving the tunnel, at £2 per load	4,724
Hoop iron for ditto, half-inch thick, and 3 inches wide, 150 tons, at £30	4,500
Covering the tunnel with 60,000 tons of clay, at 1s. per ton	3,000
Piles and sundry other timber for the works.	500
Bringing and fixing the wooden tunnel in its place, with ropes, anchors, boats, etc.	500
Keeping the engine at work one year, attendance, agency, etc., at £50 per week,	2,600
Incidental charges, 10 per cent on the whole amount	5,400
Total	£42,745"

PLAN FOR A COMBINED WOOD, CEMENT, AND CAST IRON TUNNEL.

This projector presented plans for four different sizes of tunnels, with variations of the form in each, from which the company was to choose. One plan was for a tunnel having a mean diameter of about 11 feet. The sides were to be on a curve of 12 feet diameter, the bottom on a curve of 10 feet, and the top 7 feet diameter. Another was to be 16 feet in diameter, and another 9 feet, both having varying curves. Lastly, a plain tube of 9 feet diameter was shown. The material and method of construction were the same for all.

The body of each tunnel was to be composed of segmental plates of cast iron, with projecting flanges at their four edges, turned outward, by which flanges the plates were to be fastened together with nuts and screws.

Outside the cast iron tunnel thus formed, a body of cement or hard-rammed clay, five or six inches thick, was to be laid, and the whole was to be inclosed in a casing of wooden planks.

The method of laying was to excavate under the bed of the river. For this purpose, where there were quicksands, a shield was proposed, having a face of upright bars, forming a grating, with separations of an inch and a half. It was supposed that the sand in front of the shield could be picked down into the tunnel through the bars, without danger to the workmen from too sudden an influx.

PLAN FOR A WROUGHT IRON TUNNEL, STRENGTHENED WITH CAST IRON RIBS.

This project was for a tunnel 27 feet in diameter. The cast iron ribs were to be one foot apart, three inches broad, and four and a half inches thick, scarfed at each end, the scarfs two feet long and overlapping each other, fastened with seven bolts passing through the scarfs and through the wrought iron tunnel-plates. Each rib was to be composed of sixteen pieces.

The wrought iron plates were to be rebated at the edges, two and a half feet long, the joints of one row to be opposite the middle of the plates next adjoining.

PLANS FOR DOUBLE TUNNELS IN BRICK, ALSO IN CAST IRON.

These were projected by W. Murdoch, of Paisley. One plan was for a double tunnel in brick—that is to say, tunnels, one upon the other, of elliptical form, 27 inches thick. Another plan was for a two-story tunnel made of flanched plates of cast iron, secured together with bolts, the joints of the plates calked with lead. The division consisted of an iron floor, secured to the sides, which were straight, the bottom flat, and the roof arched. Another form for the division or floor consisted in having shelves cast on the sides of the iron plates, which supported a floor in the form of a brick arch.

Another plan was for two brick tunnels, side by side, the roof supported centrally on arches. In a similar cast iron tunnel the roof was to be centrally supported on pillars. Another plan was to make a single tunnel for the greater part of the distance, with short double tunnels at intervals of 200 or 300 yards, for the passage of teams

PLAN FOR A SMALL BRICK TUNNEL, AND PECULIAR METHOD OF LAYING IT IN THE RIVER.

We come now to a novel plan for laying down a brick tunnel, which was proposed by Charles Wyatt and John Isaac Hawkins. This plan attracted great attention, and seems to have been at one time the favorite choice of the Thames Archway Company. Some of the parties interested in the company went so far as to lay down an actual section of this tunnel in the Thames river, for the purpose of publicly demonstrating the practicability and cheapness of the plan. It is a tunnel of about the same size as this that it is now proposed to be laid under the river between New-York and Brooklyn. We shall first describe the method, and then give some account of the laying of the experimental section:

Width of the Thames river at high water	847 feet.
Ditto at low water	649 feet.
Greatest depth at high water	38 feet 7 inches.
Ditto at low water	16 feet 9 inches.

It is proposed to make a brick tunnel, of a cylindrical form, ten feet nine inches in diameter outside, and eight feet six inches inside, leaving thirteen and a half inches, or one brick and a half, for the thickness of the wall. The tunnel to be built in lengths of fifty feet each, and floated over the required situation, where they are to be sunk into a trench prepared for their reception, and afterward covered over with earth even with the bottom of the river.

The particulars of the operation are detailed as follows:

1. In a dock communicating at pleasure with the river, build a cylinder with bricks laid in Roman cement, fifty feet in length.
2. Let the ends of the cylinder be formed into steps and other projections, to keep it even with the other cylinders to which it is to be joined.
3. Close the opening at each end with a hemispherical wall, and in the upper part of the cylinder, about six or seven feet from one end, fix a cast iron tube, of six inches bore, having a conical plug ground into it. To the lower end of this tube screw or bolt another tube, eight feet three inches long, and on the upper end screw or bolt a pump, of rather larger diameter, reaching at least forty-six feet perpendicularly above the cylinder.
4. At six or seven feet from the other end of the cylinder, insert a piece of iron, into which screw a mast, standing parallel with, and reaching the same height as the pump, being also of the same diameter. Both these must be supported by braces, screwed into pieces of iron fixed in the brickwork. The axes of the pump, mast, and cylinder must be all in the same vertical plane.
5. At the distance of twelve and a half feet from the ends, let into the upper part of the brickwork two iron hooks, strong enough to suspend, in water, the cylinder with its appendages. These hooks may be supported by iron hoops inclosing the cylinder.
6. Fix a cock in one end of the cylinder, near the bottom, having a lever worked by a connecting-rod forty feet long.
7. A man-hole, secured by a strong iron plate, should be left at the top of the cylinder, in case it may be found necessary to examine the inside.
8. Put inside the cylinder, for ballast, paving stones enough to form a pavement five and a half feet wide, and a sufficient quantity of pig or other iron, to make it float with the masts upright.
9. Admit water into the dock to float the cylinder; shift the ballast till it floats upright; secure the man-hole, and force the cylinder under water, where it should be kept for some time. When the work proves to be water-tight, take down the pump and masts, with their braces, observing to mark them so that they may be put up again in the same situations.
10. While the cylinder is under preparation, dig, in the deepest part of the river, and in the line where the tunnel is to be laid, a trench deep enough for the cylinder to lie in, with its upper part about six feet below the bed of the river.
11. Form a scaffold for letting down the cylinders, provide six bases of cast iron, having spikes at the under sides, somewhat like a harrow, to keep them from sliding along the bed of the river; each base having three sockets, to receive as many balls, armed with ferrules, into which common scaffold poles are fixed.

12. Lash together the three poles so that they stand perpendicular to the plane of the base.

13. Fix, by means of the poles, three of the bases in a line on each side, near the edge of the trench, sixteen feet apart.

14. Lay, across a barge, a platform, containing two windlasses, of the double-barreled kind, twenty-five feet asunder, each ten feet long; the larger diameter two feet, and the smaller twenty inches; moor the barge over the trench, untie the three poles belonging to each base, and tie them to those of the adjoining bases and to the platform, so that they form supports and braces for it.

15. To counteract the specific levity of the scaffold, load the bases with pigs of iron, let down by ropes, the ends of which may be made fast to the scaffold.

16. Put a rope of at least two inches diameter on each windlass, to suspend the cylinder by, and a pulley on each rope.

17. A steel spring should be laid under each axis of the windlasses, to indicate, by the degree of flexure, what force is at any time exerted on the ropes, by which means it will be easy to guard against overstraining them.

18. The cylinder may be guided in any lateral direction, by small ropes fastened to the scaffold, and acting on the suspending ropes at a distance below the windlasses.

19. Thus much being prepared, tow the cylinder over its destined situation, within the scaffolding; attach the pulleys of the windlasses to the suspending hooks, and erect the pump and mast in their places; turn the cock so as to let in as much water as will give to the whole a small degree of specific gravity more than water; ease it down gradually by the windlasses, until it arrives at its proper place, which will be known by the tops of the pump and masts being in a line with fixed points on the shore.

20. Throw in earth to surround the cylinder, and when it is properly bedded, let in water equal to the weight of the pump, masts, and braces; and after drawing the pump buckets, and forcing the conical plug into its place, the whole of these may be taken away, after which the cylinder may be covered with earth taken from the next excavation, even with the bottom of the river, except the ends, which must be guarded till the next lengths are down.

21. Remove the scaffolding to a new situation for putting down the next length, which will be proceeded with in the same manner as the first, taking care that the ends of the cylinders be made to fit each other, and brought into contact; but should this not be perfectly effected, the surrounding earth will form a sufficient barrier to the water, until it can be stopped from the inside.

LAYING THE SECTIONS.

A brief statement of the progress of an experiment made for the purpose of ascertaining the practicability of constructing cylinders of brickwork, and of depositing them, through the water, on a given spot in the bed of the river Thames, at Rotherhithe, with a view to the formation of a tunnel for foot passengers under the river, from shore to shore. This experiment was begun in October, 1810, and finished in June, 1811, by John I. Hawkins, engineer:

Two cylinders, twenty-five feet long, eleven feet three inches external, and nine feet internal diameter, were built of bricks laid in Roman cement; the ends of these cylinders were closed with spherical bulkheads of the same materials; a hole twenty inches in diameter secured by an iron plate was left in each bulkhead, and in the top of the cylinder; a pipe was fixed in the top of each cylinder, reaching nearly to the bottom, and a pump, twenty-five feet long, fitted to the upper end of it; an air-pipe was also made to screw over a hole left for the purpose; a cock of three inches bore was placed in one end of each cylinder; masts for sight poles, twenty-two feet long, and graduated, were erected on the ends of the cylinders, and braced from the sides.

These cylinders were built in a barge, and launched into the water by sinking the barge; they floated about two feet out of water.

An excavation was made in the bed of the river, near to low water mark, by the means commonly used for taking up ballast.

A stage was erected over the excavation, consisting of a platform, twenty-eight feet by twelve, supported on six upright legs, and kept steady by twelve very oblique braces, formed of scaffold poles and spars, from five to nine inches diameter; these poles and spars were pointed, and loaded with iron to overcome their buoyancy, and sunk into the ground by the weight of the platform, which was thirty-three feet above the bottom of the excavation, and always out of the water at high tides; on the platform were two windlasses of the double-barreled kind.

The stage, which, by reason of its numerous braces, might have borne a great shock, was nevertheless defended from the shipping by two hexagonal sets of floating booms, one set within the other, but so detached that the outer booms might be torn away by ships running against them without injuring the inner; each boom consisted of three Quebec spars of about twelve inches diameter, lashed together, and from thirty-five to forty-five feet in length; the inner booms were held by four anchors with single chains, and two anchors with double chains, the anchors being from about five hundred to seven hundred weight each; the outer tier of booms was fastened to the inner by slight ropes.

In case the anchors should yield, the booms were hindered from pressing against the stage by six piles, from ten to fourteen inches in diameter, and forty-five feet long, pointed and loaded with iron, and forced into the ground by their own weight, and braced by other smaller oblique piles, from six to nine inches in diameter.

The hull of an old vessel of one hundred and sixty tons was moored above the booms, with two anchors ahead and one astern; and a seventy-ton lighter below, with two anchors.

The object of this mode of defense was to check, by a succession and an accumulation of resistance, the force of any vessel, before it could reach the stage, and it proved effectual; for, although the outer works were much and repeatedly injured by the shipping, the anchors being often dragged and booms torn away, yet the stage remained nearly four months in the most dangerous part of the river, without sustaining any damage from the shipping, except the breaking off four or five feet of the small ends of two scaffold poles.

The stage being defended, one of the cylinders was floated under it, the ropes of the windlasses fastened to two hooks on the top of the brickwork, the pump fixed upon the pipe communicating with the inside, the air-pipe screwed on, the masts or indices erected and braced, and at high water it was sunk by letting water in through the cock, and deposited in the excavation at such a depth that the upper part might be seen at low water, where it was kept suspended while gravel was thrown down and rammed under the bottom to support it. The rammers were fifty feet long, and a little heavier than water.

The stage was then removed twenty-five feet nearer the shore, the legs and braces singly, by means of an anchor-boat, and the platform with its windlasses, etc., all together, at high water, upon four large buoys; after which the second cylinder was suspended from the windlasses in the same manner as the first. At high water the cylinder was let down to its proper depth, and moved laterally by means of ropes, until the ends of both cylinders were in contact, and their axes in the same vertical plane. A half hoop of iron which projected over the end of this cylinder rested on the top of the one before laid down, but the inshore or south end was higher by three inches than was intended.

These facts were ascertained by the tops of the four masts on the ends of the cylinders, which were at that time three feet out of water.

In this situation gravel was thrown down and rammed under the middle and north end of the cylinder; two strong poles, pointed and shod with iron, were driven down by the east side of the cylinder, and their tops secured to the platform, to prevent the cylinders being removed by the strength of the ensuing ebb tide, before a sufficient bank of earth could be thrown down to keep it stationary.

The excavation had been made deep enough, but the inshore end of the cylinder, grounding on the bank at low water the day before the operation of adjusting took place, brought so much earth down to the bottom as to prevent that end of the cylinder being lowered again as deep as it should have been by three inches; this earth might have been removed again in two or three tides, as it had been before, but under the apprehension of being ordered by the Port Committee to take the works out of the river, I determined to conclude the experiment without regard to that three inches, since the only inconvenience was a space of one inch and a half between the ends of the cylinders at the lower side, although they were in contact at the upper; and no doubt was entertained of keeping the water from passing through this space in any quantity that should hinder the calking of the joint from the inside.

At the succeeding low water, the cylinders were found to be exactly in the situation indicated by the masts at high water, after which the joint was covered with a mixture of mud and gravel; but, owing to the want of a sufficient bank of earth at the sides, it lay but a few inches thick on the top, and this, sliding off at low water, wanted that compactness which was necessary completely to stanch the joint. The influx of water, however, through the joint was scarcely eleven gallons a minute, when the water in the river stood three feet higher than that within the cylinders.

These were the principal features of the experiment. The only thing met with worthy the name of difficulty was the defending of the stage against shipping.

In proceeding with a tunnel, I would propose to adopt the modes pursued in the experiment, with scarcely any other exception than the defense, which must be more efficient and less extended, and one that can be removed and pitched again at the same time with, and while surrounding the stage.

THE THAMES TUNNEL.

England is full of tunnels, and some are of wonderful length. Before the introduction of railways, when canal transportation was all the rage, the construction of tunnels through hills and mountains was very common. Among the most remarkable of these canal-tunnels were those at Worsley, on the Bridgewater Canal, which were eighteen miles in length.

The most difficult and expensive tunnel ever constructed, considering its length and size, was the Thames tunnel. The time occupied in its completion was eleven years, and its cost was £454,714, or about $2,273,570. The total length of the tunnel, from shaft to shaft, is 1200 feet. The immense difficulties experienced, and the great outlays involved in the construction, were not due to the hard nature of the soil through which the tunnel was laid. We have already described the previous construction of the drift-way or small tunnel, which was readily carried through nearly the same route, at a small cost. We have also described several different plans which would have been much cheaper, quicker, and better. The Thames Tunnel Company deliberately selected, at the outset, the most ponderous, massive, costly, and difficult scheme of construction that could possibly have been chosen, and then adhered to their choice with a dogged pertinacity characteristic of John Bull. The company might have abandoned their plan for a simpler one at almost any stage of the work, and could have saved money by the change; but they stuck to it heroically until their treasury was exhausted. They then applied to government, and obtained aid to insure the completion, or, rather, almost the completion; for the tunnel is still unfinished. Only one of its two divisions has been finished inside, and the spiral roadways for teams, in the shafts, have never been erected. Only foot-passengers can pass through, and from these a small revenue is derived, little more than sufficient to pay the expenses of attendants, cleaning, and repairs. But this wonderful structure, solid and magnificent as it is, will not always remain an idle curiosity. All that is wanting to render it useful is the construction of proper and convenient approaches. The progress of metropolitan population and enterprise is so rapid, that every possible avenue of communication will soon be overloaded, and the Thames tunnel will probably become a great and important railway thoroughfare.

Mark Isambard Brunel was the projector and engineer of the present Thames tunnel. He was the inventor and patentee of a novel shield, intended to cover the head of the tunnel and protect the workmen while they excavated the earth under the bed of the river. The construction of the shield was such that, as fast as the excavation was made, the shield could be pushed forward and the masonry of the tunnel built up in the rear of the shield. The directors of the company appear to have been greatly struck with the merits and novelty of Brunel's shield. It was an immense machine. Its face was 38 feet wide and 22 feet 6 inches high. It was larger and heavier than many of our country dwelling-houses; and the plan was to excavate an aperture under the river-bed large enough to receive the structure and then move it through as the excavation progressed. It almost passes belief that such a huge, unwieldy machine could be pushed through the bowels of the earth, underneath a river, its waters pressing down with a force of 2500 pounds to the square foot. But the feat was actually accomplished, though at snail pace, the annual average movement being only one hundred feet a year.

Mr. Brunel once stated before the Royal Academy of Sciences at Rouen that the idea of his *shield* suggested itself to him upon an examination of the insect called the teredo, well known for its ability to bore through the largest timbers under water. Its head is protected from the water by a species of shield.

Dr. Tomlinson gives some interesting particulars concerning the building of the Thames tunnel. A vertical shaft of masonry, over 3 feet thick and 50 feet in diameter, was first sunk in the river-bed, to a depth of 80 feet. This was a most laborious and expensive work. A similar shaft was subsequently sunk on the opposite side of the river, with which the tunnel connects. During the progress of the tunnel the river burst through between the brickwork and the shield several times, and a number of lives was lost.

The excavation for the tunnel was thirty-eight feet wide, and twenty-two feet six inches high; and, in order to leave a sufficient depth of ground in the middle of the river above the brickwork, the tunnel was formed with a declivity of two feet three inches in one hundred feet. The ground above was supported while the excavation was going on by a shield, consisting of twelve massive iron frames, placed side by side, and capable of being slid forward, independently of each other, for a short distance, by means of screws abutting against the end of the completed brickwork, which followed closely on the excavation. The shield was supported on flat soles, capable of being easily moved forward. The top and sides were also closed in by flat plates, which were supported by massive framing, and also fitted close to the brickwork, by which means the soft earth was prevented from falling in. Each frame of the shield consisted of three stories, with a cell in each, in which one man could work; the front of each cell, protected by a series of narrow poling-boards, each of which was held in its place by an arrangement which allowed it to be fixed in a vertical line even with the face of the shield, or a few inches in advance thereof. Each miner began operations by removing the upper poling-board in his division of the shield, and excavating the small portion of earth thus exposed to the depth of about six inches. He then replaced the poling-board, and caused it to press, by means of jack-screws, against the face of the excavation. He next removed a second board, whereby a fresh portion of earth was exposed and excavated as before. When all the poling-boards in one frame of the shield had thus been advanced six inches, the frame itself was moved forward, and the same series of operations repeated. The frames of the shield were thus alternately moved forward, slowly and with great caution, the brickwork following close upon the shield, and inclosing two arched passages, twenty-six feet four inches in height from the invert to the crown of the arch, and thirteen feet nine inches span at the springing of the arch. This shield was so damaged in the course of the work that it had to be taken down, and a new one raised. The arch, the invert, and the curved side walls are laid in concentric rings, either a whole brick or a half brick in thickness, each ring presenting a plain face, no bond being employed between the successive rings. The tunnel is built with the hardest picked stock bricks. The first or inner ring of the arch is laid in pure cement, and the other portions of the work in half cement, and half clean, sharp sand. The bricks for the semicircular portion of the arch were moulded to the true wedge form, so that the bricks radiated with parallel joints between them. The total thickness of the brickwork at the thinnest points, where the inclosed arches approach nearest to the boundary of the rectangular mass of brickwork, is three feet. A solid wall, three feet six inches thick at the top and four feet at the bottom, was constructed between the arches; small transverse arches being afterward cut through it at intervals to form openings from one tunnel to the other. The whole of the brickwork is laid in Roman cement, and each archway is to be finished with a lining of cement, a carriage-road and a narrow footpath adjoining the central wall. Only one archway, however, has been thus completed. A brick drain is laid down from the centre or lowest point of the tunnel to the Rotherhithe shaft, by means of which any water that percolates through may be removed. The inclination of the roadway conducts the water from the other half of the tunnel into the drain.

THE SECOND THAMES TUNNEL.

A new, smaller, and cheaper tunnel under the Thames is now in progress of construction by the Waterloo and Whitehall Pneumatic Railway Company. This tunnel is to be put down substantially on the Wyatt & Hawkins plan, heretofore described. That is to say, the tubes, after completion, are to be floated to the required line, then sunk in a ditch below the bed of the river. The tubes are built upon ways, and launched like a vessel. The reader will find an engraving of one of these tubes, taken from a photographic view as it appeared before launching, on page 165 of this paper, Vol. XVI., March 16, 1867. The tunnel is to be composed of a series of ¾-inch boiler iron tubes, each 221 feet long, covered and lined with brickwork. The extremities of the tubes are to be sustained in massive iron cradles, sunk in the river below its bed, upon foundations of masonry. The internal diameter is to be 12 feet 9 inches.

THE WEYMOUTH TUNNEL.

This tunnel is 450 feet in length, excavated under the bed of the Backwater, at Weymouth, England. It was commenced by sinking a shaft, 50 feet through gravel and clay, of 14-inch brickwork, laid in hydraulic cement; the tunnel then strikes off horizontally a distance of 450 feet, with a gentle rise to the other end. The tunnel is 7 feet high, 4½ feet wide. For fifty feet near one end, where the clay is strong and retentive, the walls are only nine inches thick. The opposite shaft is forty feet deep. The depth of water over the tunnel is 13 feet at high tide, 7 feet at low tide. There was but little leakage.

The construction of small tunnels under rivers is a very easy and comparatively cheap work. It is only when we come to gigantic structures of immense weight, such as the Thames tunnel, that the costs and difficulties become serious. The Weymouth tunnel was begun in 1834 and completed in a year.

PROPOSED TUNNELS BETWEEN NEW-YORK, BROOKLYN, AND JERSEY CITY.

An organization has been made for the purpose of procuring legislative authority for the laying down of tunnels, upon the general plan just described, between the cities of New-York, Brooklyn, and Jersey City. The proposed tunnel will be cheap in construction, and is to have an interior diameter of about eight feet. The New-York termini are intended to be at or near the City Hall Park, the terminus in Brooklyn being at or near the City Hall, or the junction of Fulton and Court streets, a distance of just one mile. Trains of passenger-cars will pass through this tunnel, from end to end, in one minute, and will be propelled by atmospheric pressure. The cars will be of about the same dimensions as the ordinary street passenger-cars, will be brilliantly lighted, and run with very little noise or vibration. Experience has shown that air-pressure is preferred as a motor to locomotive or horse-power, as all jerking is avoided, and the atmospheric car glides along with a smoothness resembling that of a vessel upon the water.

The number of passengers now annually carried upon the ferry-boats between New-York and Brooklyn is 40,000,000, being an average of 110,000 per diem, or 10,000 passengers per hour, reckoning the day at eleven hours, during which period the great majority are at present carried.

In the transport of passengers through the proposed Brooklyn tunnel, trains, capable of carrying 1000 passengers, will be started from each terminus every five minutes. 24,000 passengers will thus be carried every hour, which is more than double the amount of transportation now required.

The area of the cross section of this tunnel would be about the same as the Croton tunnel or aqueduct, which is 53½ square feet. The Croton

Aqueduct, from the dam to the reservoir, is 40½ miles long, built of brick and stone. The whole cost, including dam, land, right of way, bridges, reservoir, etc., was $12,500,000. Of this amount, nearly $2,000,000 was for distributing pipes. The time occupied in construction was only five years.

THE CHICAGO TUNNEL.

Probably the longest sub-aqueous tunnel in the world is that at Chicago for supplying that city with pure water. It extends for a distance of two miles under the waters of Lake Michigan. This tunnel illustrates the cheapness and rapidity with which tubular structures of small dimensions may be cut in easy soil. The problem was, to go horizontally through a strata composed chiefly of clay. The original contract price for the entire work was $315,000. But, in consequence of the sudden great rise in prices, the amount proved inadequate. Changes were also ordered in the construction of the piers and vertical shafts, to give them greater solidity, and the contractors are understood to have received much more than the contract price. Perhaps the largest share of the whole cost was involved in the construction of the two vertical shafts, as the horizontal tunnel was easily made. The outer shaft is 66 feet deep, 9 feet in diameter, composed of cast iron, set within a coffer-dam, which is 90 feet in diameter and 45 feet deep. The interior space between the dam and the shaft is to be filled with solid stone-work, and the pier thus formed is to be surmounted with a lighthouse. The horizontal tunnel, two miles in length, was constructed in a little more than one year. It is 5 feet in diameter, composed of 8-inch brick, laid in the best cement.

TUNNEL UNDER THE CHICAGO RIVER.

The tunnel under the Chicago river, Washington street, is now progressing rapidly and favorably. The contractors are Lake Clark & Farwell. There is every prospect that the tunnel will be completed during 1868, when the people of Chicago will enjoy uninterrupted communication with the opposite bank. The whole length of the work, from the centre of Franklin street to the centre of Clinton, is 1605 feet, of which 932 feet is the length of the tunnel; the remainder consists of the open approaches.

TUNNELING THE TEES.

A late number of *Engineering* describes a plan, proposed by Mr. Head, of Middlesboro, England, for tunneling the river Tees, for the purpose of connecting Middlesboro with Norton Junction by rail. He says:

"I propose that it should be a single wrought iron tube, but divided into two passages by a water-tight web or bulkhead. This division should be strong enough to resist the pressure of the water, and preserve, at least, one side for traffic in case of accident to the other.

"As to the construction of the main tube, I would recommend something on the same principle as that exhibited in the hull of the Great Eastern steamship; that is, an outer and inner shell, for security and strength. The bottom should be made flat, or slightly arched downward. The whole section would thus resemble that of a gas-retort or culvert.

"The best plan for placing the tube in position seems to be as follows: As near as possible to the point of crossing, it should be constructed by the river side, in a temporary dry-dock formed by earthen embankments, and at such a level that the tide would float it if admitted by the removal of a dam. The tube should be erected upon timber balks, placed crosswise at intervals of 5 feet, and bolted to the structure.

" These would be floated away with it, and afterward serve as sleepers.

" Meantime, the groove in which it was intended to lie would be cut across the channel of the river by dredgers. It is no new thing to dredgr to an increased depth of 30 feet. It is, in fact, the cheapest method of excavating in all cases where it can be applied. The new Suez Canal has been greatly indebted to the use of dredging in the formation of its approaches. Dredgers have even been made to cut their way into the solid shore, the water following to float them as they made a channel for it.

"In the bottom of the groove so prepared concrete must be tipped from barges, and spread to a level by the aid of diving-bells.

" When the tube was completed, it would be necessary to cover over the ends temporarily to make it water-tight. It would then easily be floated out of the dock to its permanent position. To let in sufficient water to sink it would not occupy many minutes more. The interval between the ebb and flow, which, at spring tides, is about an hour, would be ample to accomplish every thing necessary. Concrete might then be teemed at the sides and over the top, and, in this way, assisted by the natural tendency to silt up, it would soon become permanently fixed. Embankments of clay would now be thrown out from the shore on each side of the line of the approaches, and would join across the end of the tube. As soon as they were made water-tight with clay puddle, the water between must be pumped out and the approaches built in the intervening space."

ROWLAND'S PLAN FOR SUB-AQUEOUS TUBE.

Mr. T. T. Rowland, of Green Point, N. Y., is the inventor of a method of construction which has the merit of strength and solidity. A strong tube is first made of boiler iron, which is covered and protected by means of blocks of hydraulic cement, of segmental form, fifteen inches thick. These blocks are secured by means of screw-bolts to flanges upon the exterior of the tube, the arrangement being such that the bolts and iron-work are wholly covered by the cement and carefully protected from the corrosive effects of the water. The exterior of a tube thus made would present a solid surface of hydraulic cement.

[From the " Scientific American," June 15, 1867.]

DE SENDZIMIR'S PLAN FOR A RIVER TUNNEL.

As long ago as 1857 we published (*vide Scientific American*, Vol. XII., No. 30) a plan proposed by Mr. Joseph De Sendzimir, of South Oyster Bay, Long Island, by which a passage across the East river could be secured without a structure exposed to gales, and without approaches entailing travel of three times the width of the strait. It was, in brief, similar to that now in progress across the Thames at London for the Pneumatic Dispatch. The accompanying diagram (Fig. 16) shows the plan. It was a submerged tube of iron sunk in the bed of the river, the central portion level, and the remainder rising gradually to either shore. In order to diminish the grade, the tube, on the Brooklyn side, where the natural descent is greater than on the other side, makes a curve or bend as seen in the diagram. The deepest portion of the river bed is only forty-seven feet below the surface at low water, and the tube may be either supported on piles driven into the bed of the river, or lie upon a bed scooped for it so that the top may reach only to the surface of the bed. That this plan is feasible can not be successfully denied; that it will offer no obstructions to navigation and the tides, and that it would be removed from danger of disturbance from floating ice and from gales, is susceptible of proof. Its cost,

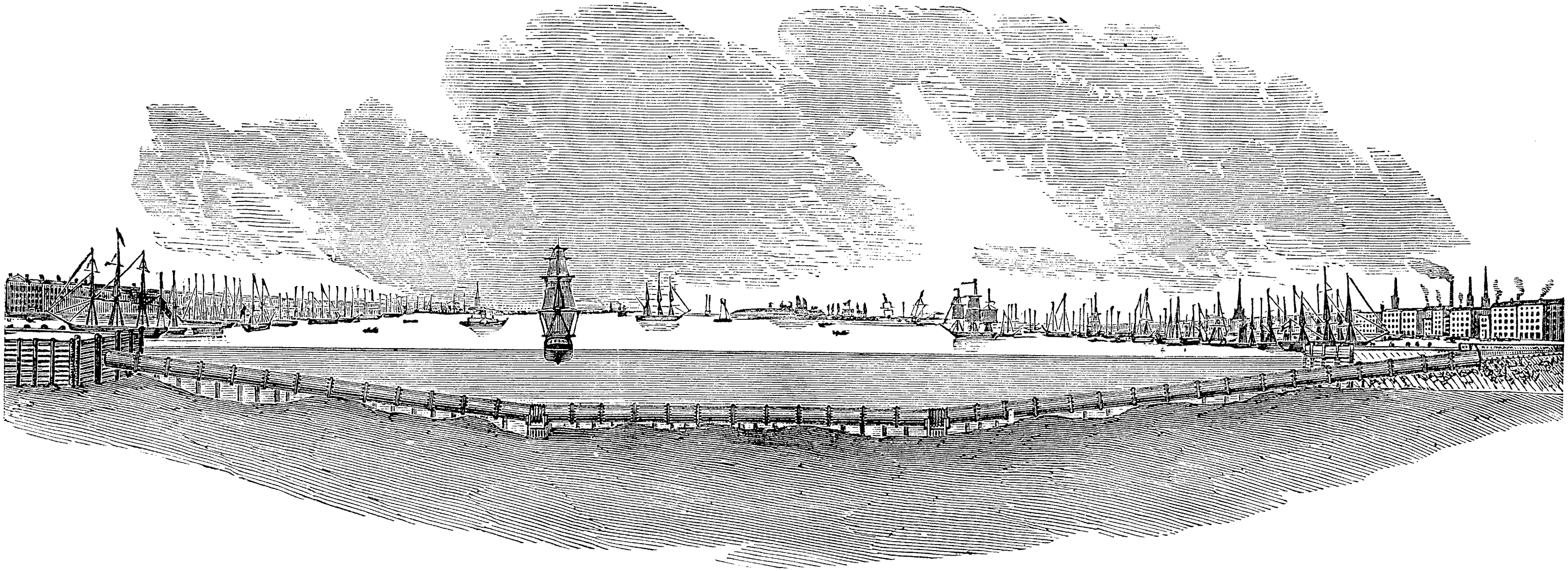


Fig. 17.—Holcomb's Plan for a Tunnel between Brooklyn and New-York

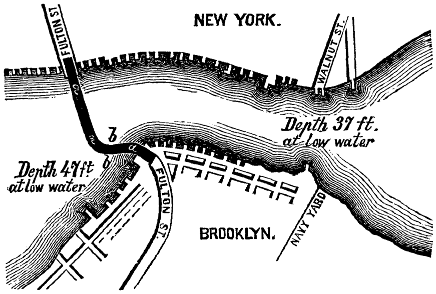


FIG. 16.—DE SENDZIMIR'S TUNNEL.

estimated at only about $200 per running foot, is so much less than that of any bridge, that twelve of these tubes could be laid for the cost of a single bridge. Its approaches could be close to the shore, and therefore not interfere with the rights of property owners. In every aspect the submerged tube appears to be better than the aerial bridge.

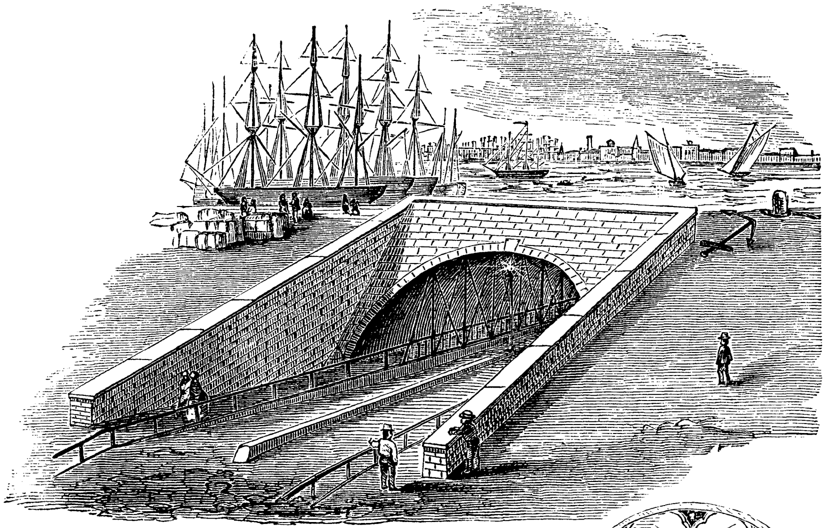
HOLCOMB'S TUNNEL.

Subsequently, as seen in No. 39, Vol. XII., 1857, *Scientific American*, we published engravings of a similar plan, which we herewith reproduce. It was suggested by H. P. Holcomb, of Winchester, Ga., and the engravings represent a profile view, and the entrances, style of tube, and a cross section. In Fig. 17, the tube is shown supported on piles sunk in the bed of the river; Fig. 18, one of the entrances; Fig. 19, across section; and Fig. 20, the construction of a portion of the tube, which is of wrought iron. Those portions which are corrugated are intended to rest on foundations of piles, and the corrugations are intended to strengthen the tube, and also to provide for any expansion and contraction. Our opinion is, that, if the whole tube was built of corrugated iron, it would be immensely stronger, and could also be made of thinner iron, thus reducing the cost.

The plan of building the tubes proposed is similar to that followed in the construction of the pneumatic tube in London; that is, that it be built in sections, the ends of which are made water-tight; and then the sections floated to place, and sunk by admitting a sufficient quantity of water, to be afterward pumped out. The joints to be made by bolted flanges.

We see fewer objections to this style of crossing rivers, especially when very wide, or where a bridge must be elevated, than to any other. If the tube is sunk in a bed dredged for it, there can be no reason why it might not last for generations, especially if, like that of the Thames, it is protected externally by courses of brick masonry. We gave an engraving and description of that tube in No. 11, current volume. No objection to the submerged tube, except the fact of its situation, would seem to obtain, which might not be equally valid when urged against the elevated bridge. Certainly teams and street-railway cars could as readily traverse the tube as the bridge. In either case, there must be an ascent and descent. But, beyond the fact of less cost in favor of the tube, there is the superiority in ease of approach, and consequent shortening of the distance. The two plans seem, at least, worthy of comparison by those interested in the subject.

Fig. 18.



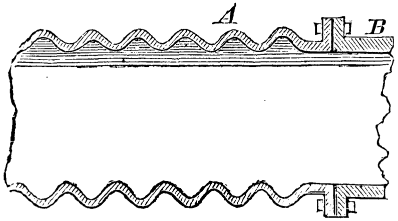


Fig. 20.

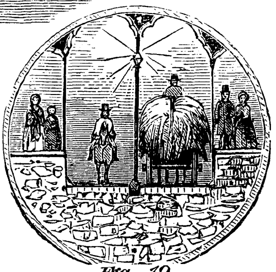


Fig. 19.

Holcomb's Plan for a Tunnel.

[From the "Scientific American," October 5, 1867.]

DIXON'S METHOD OF CONSTRUCTING RAILWAY TUNNELS.

THE problem how to relieve the city of its over-crowded population, how to extend its cramped proportions to the upper end of the island of Manhattan, how to connect it by rapid and low-priced means of communication with the neighboring shores of Long Island and New-Jersey, and how to provide comfortable and cheap homes in its vicinity for its myriad sons of toil, who labor ceaselessly to enrich grasping landlords, and who pass their hours of rest in dwellings which are a disgrace to a civilized age, is one which interests every humanitarian, every capitalist, and every lover of the city's prosperity, almost as deeply as the numerous class which is more immediately benefited by its solution.

Railroads—aerial, pneumatic, and underground—to supersede the tedious horse-cars, and bridges as a substitute for ferry-boats, have been proposed. A commission, consisting of three Senators, the Mayor of the city, the State Engineer, and the Engineer of the Croton Aqueduct Board, was appointed to sit during the recess of 1866, and inquire into the best means of affording the much-needed rapid transportation. They advertised largely, and received a great number of plans and suggestions embracing every description of railroad. After giving the matter a thorough investigation, they reported to the Legislature, last January, recommending unanimously the underground railroad as superior to all other methods for this island. Notwithstanding this report, and the numerous petitions of owners and lessees of property in favor of the measure, the Legislature refused to grant a charter to any of the numerous applicants, owing to dissensions among the parties applying. The only measure of relief (?) granted was the authority given to construct two bridges across the East river, which can not be completed in several years. The time, however, will come when public opinion will demand the adoption of all the methods that can be made available; and then the plan recently patented by Mr. Joseph Dixon, of New-York City, and illustrated in the accompanying engravings, will undoubtedly meet with the success its simplicity, economy, and adaptability for the underground and pneumatic systems deserve.

In applying Mr. Dixon's method to underground railways, the excavation is made as usual, with the exception that a much narrower trench will be needed to accommodate the iron plates forming the sides in place of stone or brickwork. A foundation of stone is then placed, to which the side plates are bolted, and the plates forming the arch are first placed on a movable framework and bolted to each other. The framework, being made so as to be raised or lowered by means of a screw-jack, will be raised slightly above the sides while the flanges of the arch-plates are being bolted together, and when ready the framework will be lowered till the arch rests in its place on the sides. A section is now complete, the centre plate acting as the key, and every joint answering as a powerful strengthening rib, and being tongued and grooved, and packed with cast iron or other cement, will be perfectly water-tight. The means of ventilation will be through iron air-shafts, rising in the form of an obelisk or column of open lattice-work, and surmounted by lamps to be used in place of the present street lamps.

For constructing the pneumatic railway Mr. Dixon's method will equally well apply where the tube is of sufficient diameter to contain the carriages, and in which they are propelled by the direct expansion of the air; the ease with which the parts are put together, their comparative cheapness in cost,

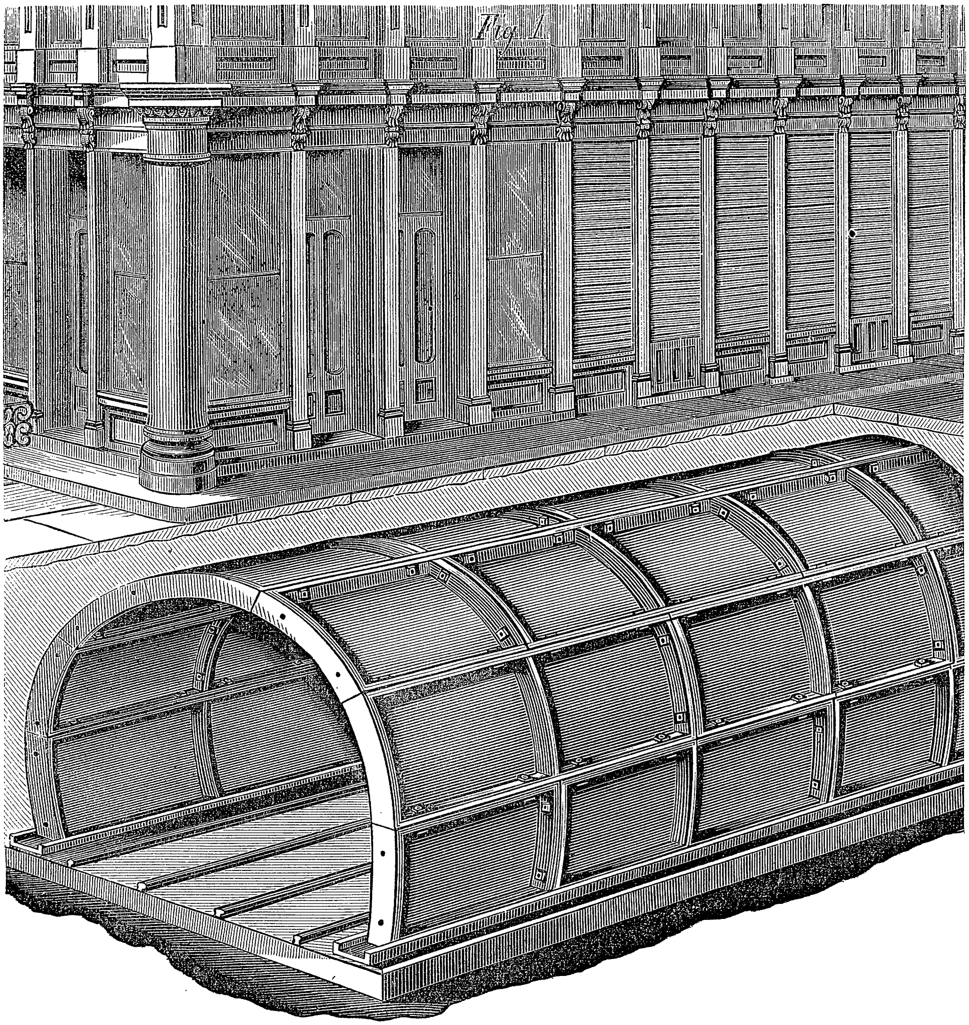


Fig. 21.—Dixon's Mode of Constructing Tunnels, Vaults, Etc.

the facility with which they may be handled and transported to the place required, render it incomparably superior to every other method of tubing hitherto employed.

For a submarine tunnel this method stands preëminent. As before remarked, the bridges about to be constructed across the East river will take several years to complete, one of them at an estimated cost of eight million dollars; for this sum several tunnels, each affording as much facility for traffic as a bridge, could be laid across the East and North rivers, and not one of them need occupy over a year in constructing.

For vaults under sidewalks, such as are used by the large newspaper establishments, and by dry-goods stores, breweries, etc., this system can be advantageously applied, and the size of the vaults largely increased by substituting the iron plates for the thick stonework and brickwork generally used.

In the construction of tunnels, where the engineer is forced to drift through a loose soil, the advantages of arches formed of these iron plates, with the joint inside, are too apparent to require any thing more than a mere mention.

[From the "Brooklyn Daily Eagle," January 13, 1868.]

COMMUNICATION WITH NEW-YORK—IS A PNEUMATIC RAILROAD FEASIBLE?

CHEAP, rapid, safe, and uninterrupted communication between Brooklyn and New-York is an essential condition of the future growth and prosperity of this city. No natural advantages which Brooklyn may possess, no attractions which we may be able to add to our city, will offset the disadvantage we now labor under in the inadequacy of the means of communication between the two cities, and the injury to which we are subjected by the interruption of this communication at certain seasons of the year. Brooklyn is destined to be the home of a large proportion of those earning a living by hand or brain in New-York City. A large local trade will necessarily follow; and in the future it may be that Brooklyn will monopolize the trade of the island lying back of it; but its main reliance will be in the advantage it may be able to hold out as a place of residence for men doing business in New-York. No advantage will offset, in the eyes of this class, the probability or possibility of the interruption of communication between the two cities. The credit of a merchant may be compromised by an hour's unexpected delay on this side of the river. The usefulness of a clerk may in a great part depend on the promptness with which he attends to his duties, and no employer will be satisfied for any length of time with the excuse that a residence in Brooklyn involves irregularity at his business. The mechanic can not afford to lose any part of his day's earnings in waiting until fogs clear off, or until the turn of the tide opens the way for boats to convey him to the scene of his daily labor. It is safe to say that there is apparently no limit to the growth of Brooklyn, save that which may be imposed upon it by the difficulty of access to New-York City.

If we had had to depend on boats moved by horse-power up to this time, it is not too much to say that Brooklyn would have remained up to this hour a village. Steam ferries met a pressing need, and have answered our purpose for over a quarter of a century. While it would not be correct to say that they have outlived their usefulness, it is safe to say that we have overtaxed their capacity as a means of communication between the two cities. Safe, speedy, and, above all, certain communication with New-York is the condition of our future growth, and no question which can be brought to the attention of our people so imperatively demands their attention as does this.

Newspapers may find fault with the ferry companies, when an accident happens, for neglecting this or that means of guarding against it; but they have a ready, and, let us add, an adequate answer to these complaints in the necessity which exists for sinking individual safety for the general accommodation. So satisfied are the ferry managers that their resources are inadequate to meet the future needs of Brooklyn, that, to every project for opening other means of communication than that the ferries offer, they seem desirous of giving a cordial coöperation.

The project of bridging the East river was discussed in Brooklyn before the commencement of the present century. Far-seeing men saw then that the first want of the city was uninterrupted communication with New-York. The appliance of steam to ferry navigation provided for immediate, and, as was believed even by the most sanguine, for future wants; but steam ferries are now as inadequate, in view of the future, as boats propelled by horse-power were seen to be forty years ago. The bridge project has therefore been revived. It finds favor from all classes; for it is seen that, whether a safe and uninterrupted means of communication between the two cities costs seven millions or seventy millions, Brooklyn in time must and will provide it. The promoters of the bridge project are not mainly interested in the enterprise as a speculation; their main object is to provide for Brooklyn the essential condition of its future growth, and this done, their main purpose will be accomplished. By a bridge seemed to be the most feasible method of connecting both cities; but fortunately, before we are necessarily committed to it, a new motive power challenges attention, and it now seems probable that through it we may secure the end we have in view, and in doing so provide for the accommodation here of five times our present population.

In the early part of the present century, a Danish engineer conceived the idea that if a tube was laid down, a box fitting in it might be propelled through it by the pressure of the atmosphere at one end, while by exhausting the air at the other, the box, with the same velocity, would rush back to its starting-point. This was the inception of what is now known as the "Pneumatic Dispatch." No practical results followed from the labors of the Dane. In 1824, an English inventor exhibited plans for a "Pneumatic Dispatch," for the conveyance of letters and packages, and he was sanguine enough to hope that passengers could be conveyed by the same means. Successive inventors took up the work of their predecessors, and in 1861 the scheme was so far perfected that a Pneumatic Dispatch Company was formed in London. An iron tube over a quarter of a mile long was laid down, and mail-bags and parcels were carried through it at any velocity required. But if parcels could be carried through, why not passengers? There was no reason why, except that adequate accommodation was not provided. The workmen from time to time accepted such accommodation as was offered, and, by reclining in the mail cars, were conveyed as safely and expeditiously as by a locomotive. The Pneumatic Dispatch was conceded to be a success, so far as the conveyance of mail matter, packages, freight, etc., was concerned.

The principle being conceded to be sound, inventors turned their attention to the extension of its application. In 1864, the tube gave place to a tunnel, which was constructed on the grounds of the Crystal Palace, Sydenham, London. By a current of air, generated by an immense fan placed at one end of the tunnel, a car carrying forty passengers was propelled through it; as the car arrived at its destination a vacuum was created by the same fan, and the car returned to its starting-point, at any required velocity. We do not desire to encumber here our statement of the main facts by a description of the machinery by which the air is propelled through the tunnel,

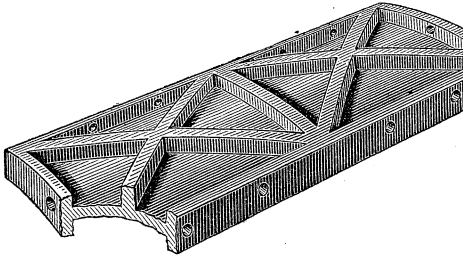


Fig. 22.

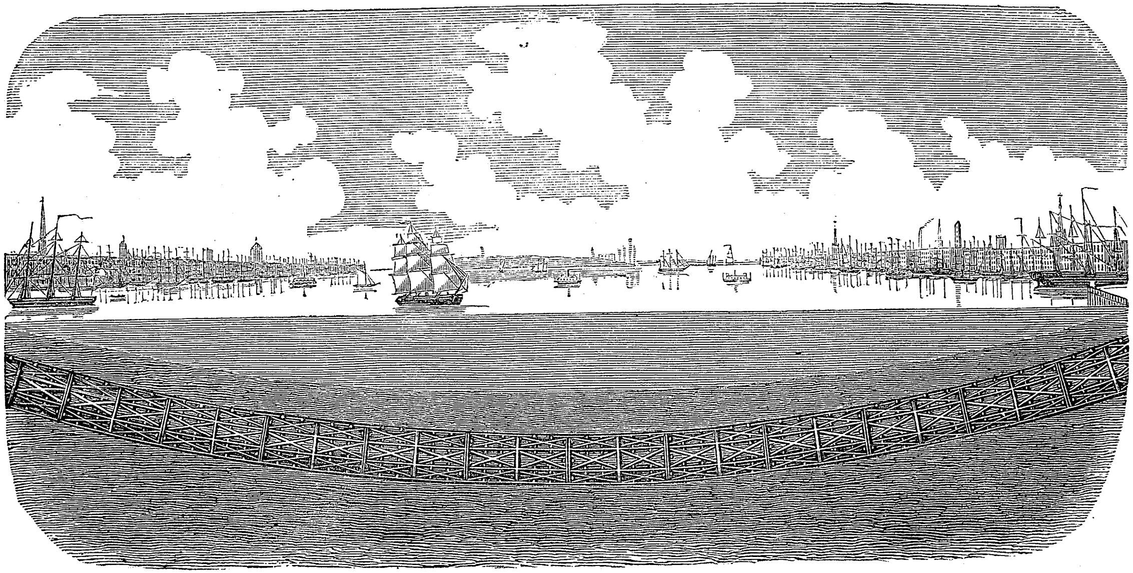


Fig. 23.

or "sucked" out of it, to use a homely but expressive word. It is enough for our present purpose to say that the question of the practicability of this part of the scheme is not open for discussion. At the late Fair of the American Institute, in New-York City, one hundred and seventy thousand people practically tested the use of air as a motive power.

Sanguine men believe that the new means of land locomotion will supersede all others now known to us. The steam locomotive, they hold, is about to yield to its supremacy, and the pneumatic car, protected from the possibility of accident, will run up mountains, along the beds of rivers, and under the streets of cities, when the steam locomotive will be as much of a curiosity as the old lumbering stage-coach now is. We need not concern ourselves with these speculations, but we are interested in the question of the feasibility of connecting the cities of New-York and Brooklyn by means of a Pneumatic Railroad.

Those interested in this enterprise are so confident of success that they ask no more from the Legislature than the privilege of being allowed to undertake it. Almost any thing is possible to modern engineering, providing money enough is furnished. It is of course possible to connect Brooklyn with New-York by an underground steam railroad; but the cost of such an undertaking would be so vast, and the difficulty of availing ourselves of steam communication buried in the earth so great, that this scheme may be dismissed as visionary or useless.

Now let us briefly state the advantage the one kind of locomotion has over the other. Steam railroads are costly in their construction and in their working, mainly because of the engine by which the motive power is generated. An ordinary locomotive with its tender weighs thirty tons; bridges, viaducts, railroad tracks, cars, etc., must be made strong enough to bear the weight, the wear, and the jar of this vast machine. The pneumatic train is propelled by a motive power existing everywhere. It weighs nothing. Thirty tons have not to be moved, as in the case of the steam-engine, before a feather's weight can be stirred. The light pneumatic car can be driven up any grade, and can be made to turn the corner of a street as safely as a horse-car. Assuming the starting-point to be at the City Hall in Brooklyn, the tunnel need not be four feet under Fulton street, and following the grade of the street until it reaches the tunnel in the bed of the East river, it will ascend the grade on the opposite side of the bank to the City Hall in New-York with any velocity that may be required. On a line from these two points it is calculated that twelve thousand persons per hour could be conveyed from one city to the other, the time of each trip being within two minutes. Access to either end of the line would be easy, for, as no grading is required, the car need not be more than ten feet below the surface. The expense of connecting these two points is estimated at a million dollars. The cost of the bridge, at the very least, will be seven millions. Or in other words, seven lines of road at seven different points may be constructed for the cost of the bridge. The latter can not be built within seven years, even if the capital required was ready to-morrow; the Pneumatic Dispatch road can be completed within a year.

If any body should deem the scheme to be visionary, his opinion may be shaken by the fact that an almost precisely similar enterprise is now under way in London, with the view of connecting, under the Thames, the two sections of that metropolis. The London scheme is a convenience, for the Thames is spanned by a dozen bridges at different points. The scheme of connecting the twin metropolis is a necessity. It seems to us that the Pneumatic Dispatch as fairly promises to meet it as any scheme which has yet been discussed. We now invite discussion for it, and we have no doubt we shall be able to answer any objections which may be offered against it.

NOVEL TUNNEL EXCAVATOR, FOR RIVERS AND LAKES—DESCRIPTION BY THE INVENTORS.

Having spent much time and thought in devising a plan for laying a tubular tunnel for railway and common roads under rivers and lakes, we have finally matured the plan we now propose to place before the public, hoping it will be examined by all who are interested in accomplishing the great object for which it is intended.

This plan contemplates laying a cast iron tube, eighteen or twenty feet in diameter, being in segments and rings, each segment being a sufficient length so that ten of them shall form a ring three feet in length, each segment to be cast one and a fourth inches thick, with a flange three inches wide, turned at right angles toward the centre of the tube, flange also to be one and a fourth inches thick.

In approaching a river or lake, we propose first to survey and examine the ground by boring, to ascertain the nature of the deposits, endeavoring by this method to avoid rocks, boulders, or other obstructions. Having completed the survey and established the grade, we now commence the work at a point above high water mark, bolting the segments together with lead joints, bolts passing through the flanges horizontally on the inside of the tube. It will here be seen that these flanges form rings entirely around this great tube, also ribs lengthwise, giving it great strength. We continue to bolt the rings together, forming this tube, proceeding down the grade until we reach a point where the water begins to interfere with the work. Here we introduce a pump, and continue the work by the common process of excavation, until the pump is found to be insufficient. Here we will cease the excavation, and continue the pumps at work. We omitted to say in our description of segments, that they are to be thoroughly coated with hard pitch, or cement of some kind, making a smooth surface on the outside.

We here apply a sliding-coffer eighteen or twenty inches larger than the main tube, by about twelve feet in length, made of boiler iron, water-tight, with a flange at its open end, eight or ten inches wide, turned at right angles toward the centre of the tube, with a follower of equal size and width of the flange, with bolt holes corresponding with the holes in the flange; this follower is to be placed inside of the coffer, some eight inches from the flange, and between which are laid six or eight inches of rubber. Having placed this follower and rubber, we now bolt through this rubber from flange to follower. We now place the coffer over the mouth or end of the tube, and slide it back some three feet; we then draw upon these bolts which pass through the rubber, making a water-tight joint on the surface of the tube. We now lay a portable track on the inside of the tube, connecting with circular cross-ties, which are bolted to cast iron staunches four inches square, standing in two rows, three feet apart lengthwise, by ten or twelve feet cross-wise, and connected at the top by circular cross-ties, forming an internal frame-work of immense strength. This portable track is to be laid eight feet wide, each rail to be three feet long, to extend from one tie to another. On this track will be placed a great supporting car eighty feet in length, made of wood, with three sets of timbers running the whole length, being bolted and braced so as to make it of great strength and weight, and placed on low wheels, on this portable track. On this great car will be placed a boiler and engine of sufficient power to do our work.

We will now introduce what we will call a great boring shaft, eighteen inches in diameter at its forward end, and eight inches at the back or rear end, and forty feet in length. This shaft is passed through the centre of this sliding-coffer, with a packed joint, and placed upon the supporting car. Upon this shaft, and in front, outside of this sliding-coffer, is placed a dredging-wheel, of equal size of the coffer, made of wrought iron and steel, cased up front and backside with plates of steel or iron, and provided with steel lags in front, and on the verge, in form of the furrows on a mill-stone. On this same shaft, inside of the coffer, and close to the journal, is a driving wheel, twelve or thirteen feet in diameter, and into it will ply a pinion and shaft six inches in diameter, running back to the engine at the rear end of the supporting car.

We now place upon the track, at the back end of this car, a portable tooth-rail, into which will ply a cog-wheel, on a system of back-gearing and feed screw, so as to multiply the power to any desired extent. We insert in the upper side of this sliding-coffer an air spout running any distance necessary to pass above the water. This spout is for purposes of ventilation, and escape of steam and smoke of the engine. Having attached the engine to the pinion-shaft by whatever back-gearing is necesary, we are now ready to stop the pumps, and let the water in; but, before we proceed to work, we will lay down the regular, permanent track, so that a construction train can pass in or out with material and fuel. We omitted to state above that this boring shaft is on a pivot-bearing at its forward end, and sliding-bearing at its back end, so that it can be adjusted in a change of the grade.

Having all our machinery in readiness, we now get up steam, start our dredging-wheel, excavating that portion of the ground which is above the water line, by common process, leaving the balance to our dredging-wheel. As this turns, it will be seen, by our description, that this car moves forward, it being connected with the sliding-coffer by four powerful and adjustable arms, the whole moving together as one body. The progress will be slow, say six revolutions per minute; while we move forward, say one sixteenth of an inch to each revolution of the wheel, varying according to the nature of the excavation. As fast as we gain three feet we bolt in one ring of our main tube. When we reach a point of sufficient depth of water, a floating dredger is used, immediately in advance of our dredging-wheel, so as to keep the top of the wheel above the ground. We now continue down the grade, sinking deeper into the water as we proceed, pressing forward with unlimited power, and by the action of this wheel against the bank, carrying up the earth at each revolution; mixing with the water, it will become liquid and pass away, leaving us a space of one sixteenth of an inch to each revolution. We speak of this progress as the slowest rate. We are very confident we can progress as fast as the construction can go on. We will now proceed down the grade, adding ring after ring to our tube, until we reach the lowest point in our specifications, which should be just the thickness of the tube below the bottom of the river. Here we change our segment pattern, so as to come to a level, and change back to straight segments, proceeding on to the opposite side of the river, where the changes will again be necessary.

This, it will be seen, is a system of progression. If we can gain one foot, we can go any distance. We have for a base this great iron structure, weighing two tons to the foot, completely buried in the ground, from which we operate with unlimited power. We have provided for displacing the water. The plan for displacing the earth has been passed upon by some of the best engineers in the country, and considered ample. In this hasty description we have omitted many things which might be said in favor of this plan, but hope its general principles may be understood.

In conclusion, we desire to say we have spent years to devise means to accomplish this great object, and believe we have succeeded. From estimates we have made we are satisfied the work can be done for less than any form of an iron bridge. The tube can be coated on the outside, and cemented on the inside, which will insure its durability, so that when once laid it may be a safe commercial highway, through which may pass a hundred generations. It will be easy of approach at either end, being only just low enough to leave the river unobstructed. The approaches may be made of other material, if found cheaper; but we are of the opinion that iron will be found the cheapest. Our estimate on an eighteen foot tube, all complete, at two tons per foot, at eighty dollars per ton, would be a hundred and sixty dollars per foot; this will be about sixty-six per cent of the entire cost, when ready for use. Now, taking into account the great advantage of a permanent tunnel passing under a river, leaving the same unobstructed, we hope it will command the attention of enterprising men who are so desirous of a better way of crossing our streams; and, especially, the attention of scientific men everywhere. We ask them to examine the plan carefully with regard to its merit or demerit.

T. A. Fisher & Son,
Beardstown, Ill.

GENERAL INDEX.

Page.

Accounts of the Pneumatic Dispatch in London 10, 12, 13
Blowing machinery, description of . . 13
Brooklyn Daily Eagle, views and reports of 77
Croydon Atmospheric Railroad . . 5, 20
Comparison of pneumatic and locomotive systems 67
Comparative economy of pneumatic railroads 30, 31
Early atmospheric railways . . . 18, 23
Engineering, views and reports of . . 70
Elevated pneumatic railway 46
East River, proposed pneumatic tunnel under 57, 69
First public trial of the Pneumatic Dispatch, Battersea Fields 7, 9
Frank Leslie's Illustrated Newspaper, views and reports of 16, 36
First trial of pneumatic passenger railway, Sydenham 18
First public trial of pneumatic railways in United States . 33, 34, 35, 36, 41, 42
General principles of pneumatic dispatch 5
Grades, the steepest easily ascertained 20, 22
Holborn-Street Station, opening of . . 15
Heating and ventilating pneumatic cars 46
Inspection by the Postmaster-General . 10
Illustrated News, views and reports of 22
Incorporation of Whitehall Pneumatic Railway. 23
Is a pneumatic railway feasible? . . 77
Laying down of the Pneumatic Dispatch in London 10
Load and velocity of car at Battersea . 8
Mechanics' Magazine, views and reports of 7, 10, 11, 16, 18, 23, 29
Medhurst's pneumatic railway . . . 18
New-York Herald, views and reports of 26
New-York Times, views and reports of 33

Page.

New-York Tribune, views and reports of 42
New-York City, street traffic of . . . 55
North River, proposed pneumatic tunnel under 57, 69
Novel tunnel excavator 81
Pneumatic tunnel at Sydenham . . . 20
Pneumatic railway tunnel under the Thames 25
Pneumatic railway under the streets of London 23
Pneumatic *vs.* Locomotive railways. . 29
Pneumatic railways in Switzerland. . 33
Pneumatic railway in the United States, first trial of 33
Pneumatic Postal Dispatch . 35, 38, 42, 48
Projected pneumatic railways . 35, 36, 44
Practical Mechanics' Journal, views and reports of 12
Passengers, number carried, Brooklyn Ferries 69
Report of the Directors, Pneumatic Dispatch Co., London 11
Scientific American, views and reports of 9, 27, 33, 41, 46, 57, 71, 75
Steam Tunnel Excavator, Fisher's . . 81
Sub-aqueous pneumatic dispatch . . 28
Stopping at way stations 45
The Engineer, views and reports of . . 9
Thames Archway Company 58
Taking letters from the lamp-post . . 54
Tunnel, sub-aqueous, various plans for 58
  " Trevethick's, drift under the Thames. 58
  " brick, plan for 59
  " cast iron, Trevethick's . . . 59
  " combined wooden, cement and iron 61
  " Croton aqueduct 69
  " Chicago, at 70
  " double 62
  " De Sendzimir's river 71